LIVING IN SPACE

NASA-EP-223

(NASA-EP-223) LIVING IN SPACE, BOOK 2, LEVELS D, E, F (NASA) 70 p CSCL 06K

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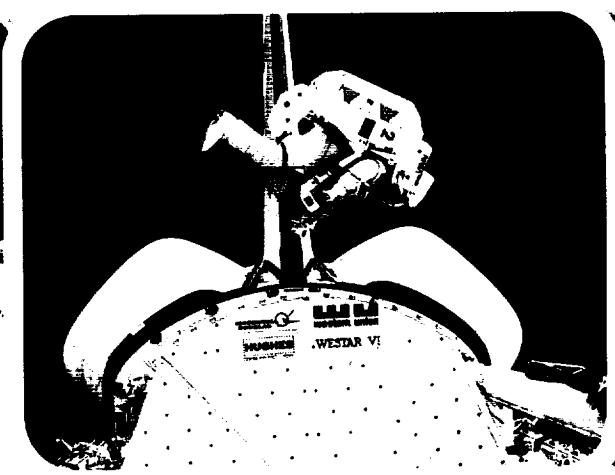

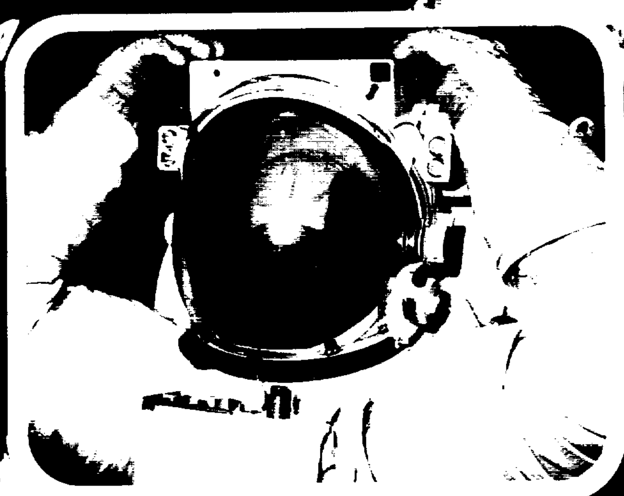

OPERATION LIFTOFF

Elementary Space Program

A Resource Guide With Activities For Elementary School Teachers

BOOK II

Levels D, E, and F for grades 4, 5, 6

- FOOD
- CLOTHING
- HEALTH
- HOUSING
- COMMUNICATION
- WORKING

LIVING IN SPACE

OPERATION LIFTOFF
Elementary School Space Program

LIVING IN SPACE

BOOK II

Levels D, E, F

Authors: Sheila Briskin Andrews
Audrey Kirschenbaum
Illustrator: Robert Ritter

Books in this Series

Living in Space
Astronomy
Space Transportation
Space Futures

Developed by Science Weekly, Inc., Washington, DC

NASA EP-223

National Aeronautics and
Space Administration
Washington, DC

1987

Produced by IRM Corp., Nyack, NY

Senior Editor	Evelyn Rothstein, Ed.D.
Program Development	Diane Gess, Ed.D.
Project Coordinator	Sheila Briskin Andrews, M.A.
Science Consultant	Henry Schult, Ed.D.
Education Consultant	Nolan Estes, Ph.D.
Senior Science Editor	Claude Mayberry, Ph.D.
Cover and Text Design	Valerie Coll
Typography	Post Script
Project Editors	Maxine Bartow and Lynne Lauber

Photographs courtesy of NASA

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

LIVING IN SPACE
BOOK II
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INTRODUCTION

In June 1984 President Reagan announced a new NASA education program, "Operation Liftoff": "For more than 25 years NASA has pioneered on the cutting edge of science and technology and has stimulated our young people to strive for excellence in all they do." This program is designed to encourage pupils in the nation's elementary schools to take a greater interest in mathematics and science.

NASA responded to this announcement with a plan to reach students in their formative years in the elementary grades. Operation Liftoff complements the widely acclaimed educational programs NASA now offers at the secondary and university levels.

To support this project, NASA is developing new educational products which utilize the latest in educational technology. These include not only publications and videotape packages, but computer software and laser disc products. A Teacher Resource Center has been established at each NASA Center, where teachers can copy the aerospace materials to enhance their teaching of aerospace concepts.

NASA is deeply indebted to these people who contributed to the sucess of this project: Deborah Rivera, Project Officer for Operation Liftoff, overall coordinator for this project; Larry B. Bilbrough and Muriel M. Thorne, NASA Educational Programs Officers; Dr. Harry B. Herzer, III, Dr. Doris K. Grigsby and Clarice F. Lolich, NASA Aerospace Education Program Specialists; and Pamela M. Bacon and Katherine S. Forsythe, educational consultants to NASA.

William D. Nixon
Chief, Elementary and
Secondary Programs Branch
National Aeronautics and
Space Administration
Washington, DC

F O O D

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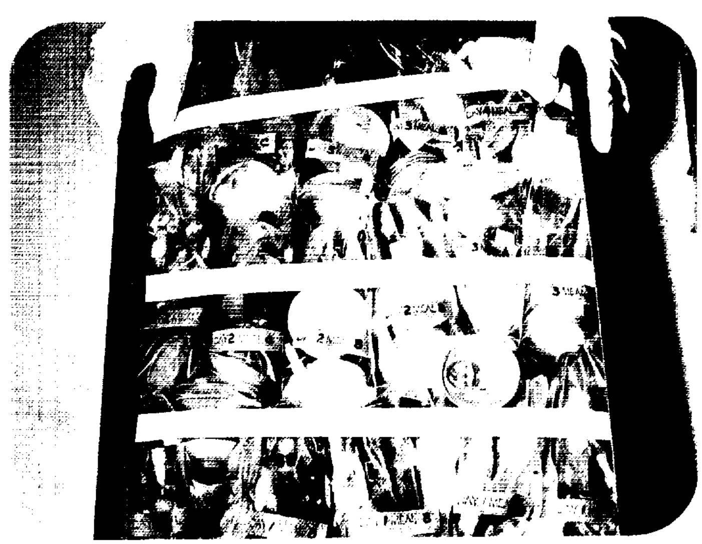
BOOK II

LIVING IN SPACE



BACKGROUND INFORMATION

Concepts

Scientists have designed a Space Shuttle food system that includes

- special utensils for eating
- an all-in-one food-preparation area (modular galley)
- safe, nutritious food in lightweight, compact packaging

Eating in Space

Weightlessness is a special condition that affects the way astronauts eat in space. Space travelers can eat standing up or sitting down leaning forward. Suction cup assemblies are attached to the astronauts' boots to help the astronauts stay in one place. However, sometimes the astronauts eat as they are floating through the cabin or while in an upside-down position.

In the early days of the space program, scientists found that food served in an open bowl could float around the cabin. The discovery that food in gravy or a thick sauce sticks to the side of the bowl led to a change in the way astronauts eat. Squeeze pouches were replaced with flatware and plastic sealed dishes. Foods cling to the top as well as the bottom of these utensils. However, with a regular size spoon, you will take too large a portion of the food. You could knock off the excess food against the inside of the bowl, but a better solution is to use a three-quarter-size utensil, similar to the silverware used on an airplane. Because sudden moves causes food to float away, astronauts must eat slowly and carefully.

The Shuttle Kitchen

The food-preparation facility, called the galley, is designed to accommodate missions of different lengths and different numbers of crew.

This facility is located in the mid-deck cabin, which is the main living area. The galley is modular and can be removed for special missions that require additional interior space. Although there is no refrigerator, there are conveniences such as hot- and cold-water dispensers, a pantry, an oven, food-serving trays, a personal hygiene center, a water heater, and extra equipment-storage areas. The convection oven has a temperature range of 65° C to 82° C and can heat containers of different sizes.

Each day three meals are prepared from a selection of about a hundred food items and twenty beverages. Menus repeat after six days. The pantry provides food for snacks and individual menu changes. Contingency food to last for ninety-six hours is also stored in the pantry.

Safe, Nutritious Food

The food system is designed to be nutritious and appetizing. The daily food supply, totaling three thousand calories before snacks, contains ample amounts of potassium, calcium, and nitrogen — minerals that the body loses in weightlessness. Loss of these minerals affects muscle tone, bone mass, ability to concentrate, and disposition.

Food aboard the Shuttle must have a shelf life of six months at 37.7° C. To meet weight and storage restrictions, food is packaged in a variety of forms: *dehydrated* (having water removed), *freeze-dried* (vacuum drying in a frozen state), *thermostabilized* (cooked at moderate temperature and sealed in cans), *irradiated* (preserved by exposure to ionizing radiation), *intermediate moisture process* (removing part of the water), or *natural* (in its original form). The food system relies heavily on dehydration because water is readily available as a by-product of the fuel cell system. Over a hundred different food items, such as cereals, spaghetti, scrambled eggs, and strawberries, go through this dehydration/rehydration process. Twenty varieties of drinks, including tea and coffee, are also dehydrated. Cans, flexible pouches, and semirigid plastic containers are used for packaging. Meal preparation for a crew of seven is accomplished in about 30 minutes.

TEACHER PRINTOUT

Objectives

Students will understand the following:

- Three-quarter size utensils are used to make eating easier.
- Astronauts eat slowly and carefully.
- Astronauts use their personal preference to decide whether to sit or stand while eating.

Vocabulary

Have the students use these words as part of your motivating discussion and in the follow-up *Space Lab* and *Space Countdown* activities.

- three-quarter size spoon (similar in size to airline silverware)
- weightlessness (subject to little or no gravitational force)
- suction cups
- utensils

Motivation

1. Describe the actions of a baby eating.
(Messy, throws food around, dribbles, waves spoon in the air, tries to put too much in mouth at one time.)

2. Ask students: How do you eat? Compare your actions with the baby's actions.
(Accept all relevant student responses.)

3. Where else can you eat if you don't have a table?
(Accept all relevant responses.)

Activity Description

The *Student Liftoff* page for this lesson contains two activities: *Space Lab* and *Space Countdown*.

The *Space Lab* is a hands-on experiment in which students compare the use of a regular-size spoon and a three-quarter size spoon. The students are asked: How does using a small spoon help an astronaut eat slowly and carefully? This experiment simulates eating aboard the Space Shuttle. This activity may be done at school or at home.

The *Space Countdown*, a math activity, requires the student to compute the total amount of calories consumed by an astronaut at one meal. The student uses addition, subtraction, and multiplication. (Answers: **1.** 917 calories; **2.** 730 calories; **3.** 187 calories.)

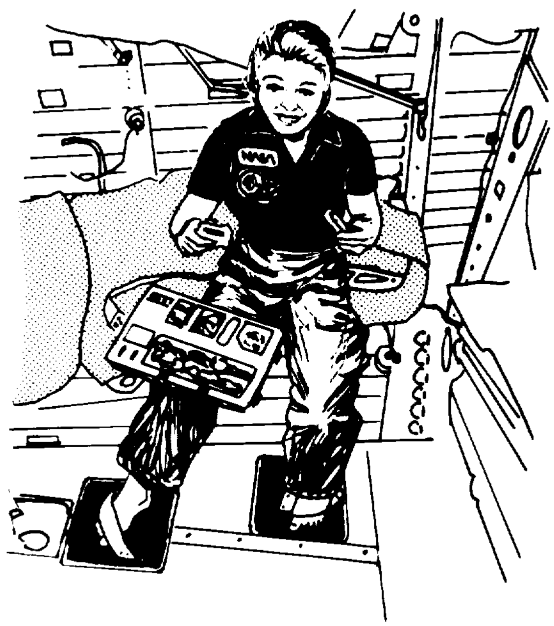
Additional Activities for School or Home

- Have students stand on their heads on a mat and rest their feet against the wall. Have them try chewing and swallowing a bite of a fruit. Ask them to describe what happens. Can they explain why this happens?
- Have the students write a story in which the main character is on a spacecraft for the first time. Use as many of these words as you need to describe the problems this person has when eating in space.

utensil	floating	crumbs
suction	flyaway	messy
weightless	movement	boots

- Have students pretend to be inventors. Ask them to design the perfect space utensils. Have them draw diagrams of their inventions and explain how they work.

STUDENT LIFTOFF



If you had a choice, how would you eat? Hanging from your heels, sitting up, or standing? These are some of the choices astronauts have aboard the Space Shuttle. To keep from floating while eating, astronauts anchor themselves to fixed objects such as foot stirrups or wedge themselves in a corner.

In the weightlessness of space, gravy and sauces cling to the sides of food containers. Too much food clinging to the top and bottom of regular-size utensils makes eating messy. Three-quarter-size spoons and forks are now used to make eating easier. Astronauts learn to eat slowly and carefully aboard the Shuttle because sudden movements can make them or their food float away.

Space Lab

How does using a small spoon help an astronaut eat slowly and carefully?

You need: two cans of chocolate pudding, one regular teaspoon, one small plastic spoon or an airline teaspoon, a clock with a second hand.

Step 1. Eat one can of pudding with the regular teaspoon.
Time how long it takes to finish the pudding.
Eat slowly and carefully the way an astronaut would.

Step 2. Repeat step 1 using the second can of pudding and the small teaspoon.
How long did it take to eat the pudding with the regular spoon?
With the small spoon?
Which spoon made you a more careful and slower eater?
How is using a small spoon similar to how an astronaut eats in space?

Space Countdown

Space Lunch Menu

Food	Calories	Food	Calories
macaroni and cheese	309	bread (1 slice)	75
asparagus/sauce	85	shortbread cookies (1)	45
green beans/sauce	63	chocolate pudding	175

1. For lunch, one astronaut ate an extra slice of bread and two extra cookies. What was the total calorie count of the meal?
2. One astronaut had one extra portion of green beans with sauce and no asparagus. What was the total calorie count of the meal?
3. How many more calories did the first astronaut eat than the second?

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TEACHER PRINTOUT

Objectives

Students will understand the following:

- The galley is a modular unit.
- The galley provides for heating, rehydrating, and assembling meals.
- The galley is an all-inclusive food-preparation area.

Vocabulary

Have the students use these words as part of your motivating discussion and in the follow-up *Space Lab* and *Space Countdown* activities.

- galley (food-preparation area)
- chow line (food line)
- modular (having preassembled self-contained parts)
- rehydrate (add water to food)
- pantry (place to store food)
- dispenser
- mid-deck
- assembled

Motivation

1. Describe the different parts of a kitchen.
(Kitchens have stoves, refrigerators, sinks, dishwashers, electrical appliances. Accept any related answer.)

2. How is each part used in food preparation?
(The sink and dishwasher are used for washing and cleaning up. The stove, refrigerator, and electrical appliances are used to heat and cool foods.)

3. What foods would be unavailable without refrigeration?
(Any foods that would spoil at normal room temperatures, such as dairy products, vegetables, fruits, cold drinks, ice cream, and frozen foods.)

Activity Description

The *Student Liftoff* page for this lesson contains two activities: *Space Lab* and *Space Countdown*.

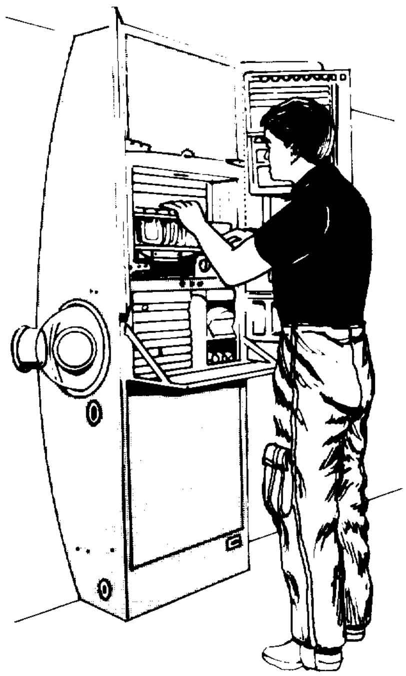
The *Space Lab* is a hands-on experiment that has students rehydrating foods to simulate a meal in space. Students are asked: How do you prepare a Space Shuttle breakfast? The foods used in this activity come in the forms indicated by the letters in parentheses: (R) stands for rehydratable; (FD), freeze-dried; (NF), natural form. This activity may be done at school or at home.

The *Space Countdown*, a math activity, requires the student to read a circle graph, use common denominators to change fractions, and compare fractional values. (Answers: 1. Rehydrated food is used most often; 2. Natural and rehydrated forms are used half the time; 3. Irradiated and intermediate moisture are used as much as natural forms.)

Additional Activities for School or Home

- How would you improve the Space Shuttle galley? How would you provide more storage space in the same area? What appliances would you find helpful? Why are these improvements important? Design your "dream" galley and create a scale drawing of the design on graph paper.
- Explorers coming to the New World faced problems involving food storage, food preservation, and food preparation. Storage room was limited. Refrigerators did not exist. Cooks on sailing ships worked in a small, crowded space called a galley. Have students compare the problems of the early explorers with the problems of today's space explorers.

STUDENT LIFTOFF



Come and get it! The chow line forms on the right!

The Space Shuttle galley, a modular unit, is located in the mid-deck area. The galley has a pantry, an oven, food-serving trays, hot- and cold-water dispensers, a water heater, and additional equipment-storage areas. There is no refrigerator.

The oven heats containers of different sizes and shapes to 82° C. Food for meals and snacks is specially treated before launch, and then stored in the pantry at room temperature.

A crew member prepares a selected meal in thirty minutes. Food is rehydrated, heated, and then assembled on the food trays attached to the doors of the galley. The galley is an all-in-one food-preparation area.

Space Lab

How do you prepare a Space Shuttle breakfast?

You need: a powdered egg (R), Tang (R), a measuring cup, a freeze-dried banana (FD), a roll (NF), an electric Teflon-coated frying pan, a three-section aluminum foil tray, a glass, salt and pepper packets

Step 1. Add water to Tang.

Step 2. Add water to egg. Beat and scramble in pan.

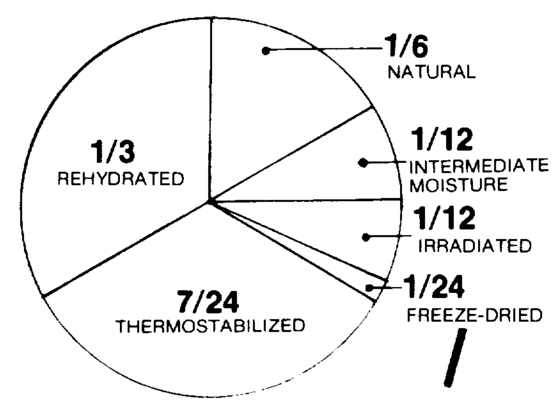
Step 3. Place egg, roll, and banana in tray sections. Eat breakfast.

How did you rehydrate the egg and the Tang?
How is the freeze-dried banana rehydrated?
Compare preparing a space breakfast to preparing an Earth breakfast.

Space Countdown

Study the graph. Then answer the questions.

1. What food form is used most often?
2. What two food forms are used half of the time?
3. What two food forms are used as much as natural form?



TEACHER PRINTOUT

Objectives

Students will understand the following:

- The Space Shuttle's food system must be appetizing, safe, and nutritious (biological factor).
- The food must not spoil and must be easy to prepare (operational factor).
- The food must be lightweight and compactly packaged (engineering factor).

Vocabulary

Have the students use these words as part of your motivating discussion and in the follow-up *Space Lab* and *Space Countdown* activities.

- fuel cells (devices that react hydrogen with oxygen to produce electricity and pure water)
- compact (condensed)
- processed (treated or prepared by a special method)
- by-product (a product produced in the making of something else)

Motivation

1. How important are our senses of smell and sight to our enjoyment of food?
(They make our mouths water, increase our appetites, make eating a pleasurable experience.)

2. How often do we eat the same foods?
(Accept all responses that explain why certain foods are eaten more often than others. Some people have the same foods for breakfast or lunch every day. Some people have the same foods for holidays.)

3. Why is eating more interesting when menus are varied?
(We don't get bored eating the same foods. We learn to try different foods that we might never try on our own.)

Activity Description

The *Student Liftoff* page for this lesson contains two activities: *Space Lab* and *Space Countdown*.

The *Space Lab* is a hands-on experiment in which students rehydrate a food product. The students are asked: Why are rehydrated foods used in the Space Shuttle food system? The experiment has the students compare the weight of soup mix and cocoa in dry form and then in rehydrated form. This activity may be done at school or at home.

The *Space Countdown,* a math activity, has students read a chart to compute the nutritional value of different foods as percentages of daily needs. This activity uses metric units. (Answers: **1.** Egg: Protein, 10.7%; Calcium, 9.3%; Iron, 25.6%; Cornflakes: Protein, 3.6%; Calcium, 0.5%; Iron, 2.2%; Banana: Protein, 1.8%; Calcium, 1.1%; Iron, 7.8%; **2.** 16.1% Protein; 10.9% Calcium; 35.6% Iron.)

Additional Activities for School or Home

- Visit the food section of a camping store. Identify dehydrated, freeze-dried, and thermostabilized foods. How is each type of food packaged? What are the advantages of these foods for space travel? Sample some freeze-dried ice cream. Compare its appearance, taste, and texture to regular ice cream.

- Have students prepare sample menus for a six-day cycle aboard the Shuttle. Consider appearance, nutrition, the absence of refrigeration, and the use of dehydrated foods. Here is a list of some foods eaten in space:

applesauce	cereal	green beans
bananas	chicken and rice	nuts
beef almondine	cookies	puddings
beef stroganoff/noodles	eggs	spaghetti/sauce
bread	food bars	tuna
apple drink	cocoa	grape drink

STUDENT LIFTOFF

Imagine having to design a food system that is compact, lightweight, easily handled in a weightless environment and serves safe, nutritious food. This is what scientists designed for the Space Shuttle missions.

On early space flights, meals were unappetizing. Today, Shuttle food tastes good, is easy to eat, and does not cause digestive problems.

Since there is no refrigeration system, food is processed to last for more than six months. The food is packaged for easy preparation by the crew and menus vary for a six-day cycle.

Because water is available as a by-product of the fuel cells, many dehydrated foods are used. All food is stored in lightweight, compact containers. The food and packaging are designed to survive the acceleration, extreme temperatures, and vibration of a Shuttle flight.

Space Lab

You will need an adult to help you with this experiment.

Why are rehydrated foods used in the Space Shuttle food system?

You need: a bowl, a single-serving package of a soup mix, 250 milliliters of boiling water, 5 teaspoons of cocoa mix, 250 milliliters of hot water, a cup, a scale

Step 1. Weigh the empty bowl.
Empty the package of soup mix into the bowl.
How much does the soup mix weigh?

Step 2. Add the boiling water to the soup mix.
How much does the rehydrated soup weigh?

Step 3. Repeat steps 1 and 2, using the cocoa, the cup, and the hot water.
Why is dehydrated food taken on a space mission?

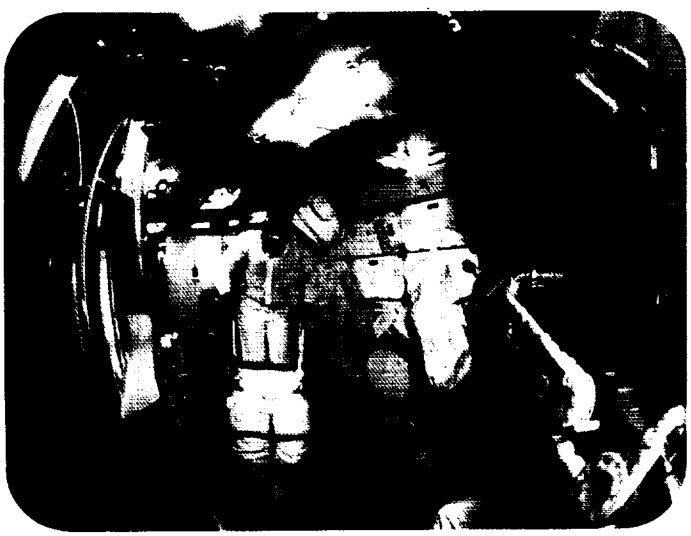
Space Countdown

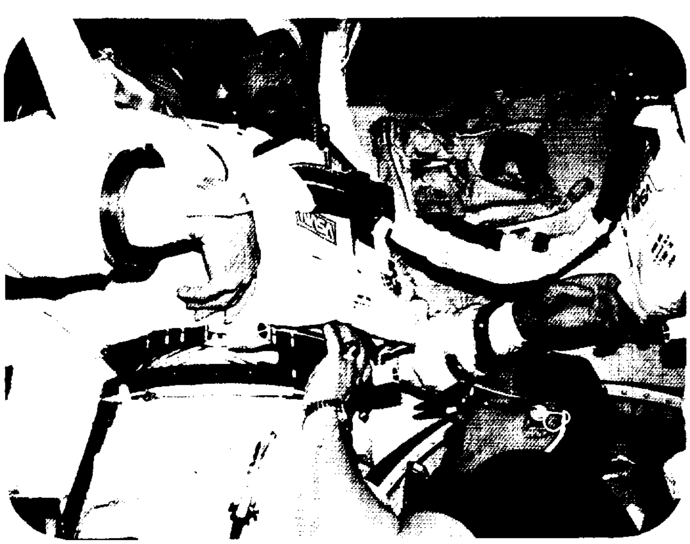
Daily Nutritional Needs		(Food) Nutritional Value			
		Amount	Protein	Calcium	Iron
Protein (grams)	56	Egg (1 large)	6	74	4.6
Calcium (milligrams)	800	Cornflakes (250 milliliters)	2	4	0.4
Iron (milligrams)	18	Banana (1 medium)	1	9	1.4

1. What percentage of daily nutritional needs does each food provide?
2. What percentage of daily nutritional needs does the entire breakfast provide?

NOTES

C L O T H I N G





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BACKGROUND INFORMATION

Concepts

The Space Shuttle requires space suits that are of a more advanced design than those used on previous missions. The Shuttle suit combines

- a self-contained life-support system for the astronaut
- a special modular design
- three main parts: (1) a liner; (2) an upper and lower torso, gloves and helmet; and (3) a primary life-support system backpack

Space Suit History

The Space Shuttle cabin provides a comfortable Earthlike environment for astronauts traveling in space. Astronauts leaving the Shuttle cabin in order to work in the cargo bay or in space must carry part of that environment with them. The purpose of the space suit is to provide air, pressure, and moderate temperatures. Space suits used on earlier missions protected the astronauts, but they had a variety of design problems. The garments were custom-fitted, and sometimes more than seventy individual astronaut measurements were required to ensure proper fit. A space suit could only be worn by one astronaut for one mission. Space suit joints were rigid, and an astronaut needed great strength for even simple movements. It took over an hour to put on the space suit and required the help of a second person. Today's new space suits have come a long way.

Primary Life-Support System

The Primary Life-Support System (PLSS) consists of two parts: a backpack unit, and a control-and-display unit on the suit chest. The PLSS is permanently mounted to the hard upper torso of the suit. The backpack unit supplies oxygen for different purposes: breathing, suit pressurization, and ventilation. The PLSS also cools and circulates water used in the liner, controls oxygen temperature, absorbs carbon dioxide, and removes odors from the suit's atmosphere. The front of the PLSS is a control-and-display unit, from which a microprocessor automatically provides start-up instructions, checks out the major functions of the suit, and warns the astronaut of any malfunctions. The microprocessor is actually a computer on a tiny circuit chip.

Modular Design

The new suits developed for Shuttle astronauts offer many improvements over earlier suits. They are more comfortable, more convenient, and more mobile. The garment is modular in design, with many interchangeable parts. The upper torso, lower torso, pants, arms, and gloves are made in different sizes and can be assembled for each mission in combinations needed to fit individual astronauts. The suits, using this design, can be worn on more than one mission, making them more cost-effective than earlier garments. Shuttle astronauts wear the suits when they assemble structures in the cargo bay, deploy payloads, and service and repair satellites.

Space Suit Components

The new space suit is called an EMU (extravehicular mobility unit) It has three main parts: (1) the liner; (2) a pressure vessel; and (3) a Primary Life-Support System (PLSS). The unit also includes a drink bag, a communications set, a helmet, and a visor assembly. The suit liner looks like a pair of stretchy long johns laced with plastic tubes. Water circulates through the tubes to help dissipate body heat. The pressure vessel is a multilayered garment that uses oxygen to maintain suit pressure. Layers of aluminized Mylar plastic and unwoven Dacron insulate the suit. A single outside layer, made of Teflon and other materials, acts as a tear-resistant cover and a micrometeorite shield. The primary life-support system completes the EMU.

TEACHER PRINTOUT

Objectives

Students will understand the following:

- An astronaut's white space suit provides air, pressure, and controlled temperatures.
- Astronauts must wear space suits to work in the cargo bay or in space.
- Present-day space suits are modular and reusable.

Motivation

1. Why are emergency oxygen masks available on airplanes and in ambulances?
(May be needed if air pressure drops in an airplane. Used to give people oxygen if they have trouble breathing.)

2. Why are houses and roofs white or light-colored in warm climates?
(Light colors do not absorb as much heat as dark colors. Light colors reflect the Sun's rays away from the roof.)

3. Why is it important for gloves to come in many sizes?
(Gloves must fit snugly in order to feel and pick up small objects. A good fit allows for manipulation of objects and materials.)

Vocabulary

Have the students use these words as part of your motivating discussion and in the follow-up *Space Lab* and *Space Countdown* activities.

- micrometeorites (masses of matter the size of grains of salt; dangerous owing to their great speed)
- cargo bay (large main body of the Shuttle where the payload or cargo is stored)
- modular (having separate self-contained parts)
- torso (body excluding head and limbs)
- EVA (extravehicular activity, popularly referred to as a space walk)
- miniature
- life-support
- portable
- reserve

Activity Description

The *Student Liftoff* page for this lesson contains two activities: *Space Lab* and *Space Countdown*.

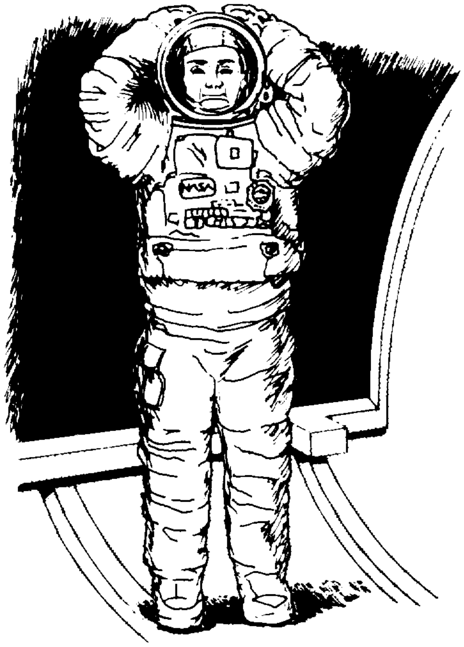
The *Space Lab* is a hands-on experiment in which students learn how color can be used to control temperature. The students are asked: Why are space suits white? A jar covered with black paper, a jar covered with white paper, and an uncovered jar are used to understand this concept. This activity may be done at school or at home.

The *Space Countdown,* a math activity, uses addition and division to find the average size of gloves, pants, and upper-torso units used by astronauts. You may wish to review the concept of finding averages. Remind students to add and then divide by the number of items added. Pants and torso measurements are in metric units (centimeters). (Answers: gloves, size 7; pants, 78.5 cm; torso, 45 cm.)

Additional Activities for School or Home

- Astronauts wear helmets as part of their space suits. Have the students create space helmets, using such materials as an empty cardboard container, small rectangular boxes, string, cellophane, pipe cleaners, and brass fasteners. Cut the cardboard container so that it fits over a child's head. Cut out a rectangular opening at eye level.
- Place equal amounts of ice in a brown paper bag and a metallic ice-cream bag. Seal the tops. Observe what happens. Which bag of ice melts first? Why? How does material affect temperature? Discuss how both the kind of material and the color of the material affect temperature.

STUDENT LIFTOFF



Have space suit, will travel.

An astronaut's white space suit is like a miniature home in space. The suit provides a complete life-support system as well as protection from dangers such as micrometeorites. Astronauts must wear space suits when they work in the cargo bay or when they are outside the spacecraft to repair satellites in orbit.

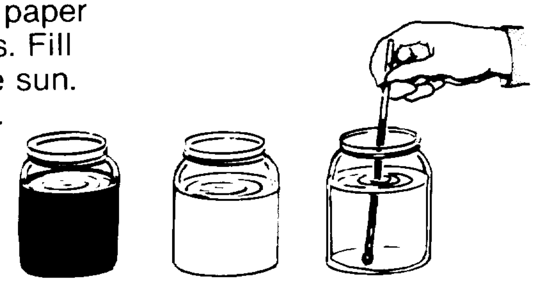
In the early days of the space program, space suits were custom-fitted and could only be worn by one astronaut for one mission. Starting with the Space Shuttle, new modular suits were developed. The torso, pants, arms, and gloves come in many sizes and can be put together for each mission to suit each astronaut.

Space Lab

Why are space suits white?

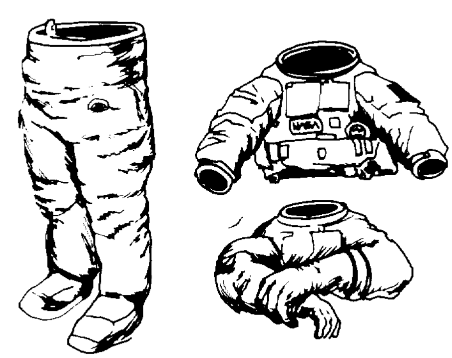
You need: 3 empty jars, 3 thermometers, black paper, white paper, tap water, masking tape

Step 1. Cut black paper to wrap around one jar. Cut white paper to wrap around second jar. Leave the third jar as is. Fill the three jars with tap water and place them in the sun.



Step 2. Measure and record the temperature of each jar after 10 minutes, 15 minutes, 20 minutes.
What happens to the water in each jar?
How can color be used to control temperature?

Space Countdown



Astronauts' modular space suits come in different sizes.
The chart shows the sizes some crew members would wear.

	GLOVES	WAIST (cm)	TORSO Neck to waist (cm)
Anna	6	74	40
Buzz	7	80	47
Robert	8	85	50
Kesha	7	75	43

What is the average glove size? Pants size? Upper-torso size?

TEACHER PRINTOUT

Objectives

Students will understand the following:

- Shuttle space suits have a modular design.
- The underlayer provides a comfortable temperature.
- An insulating layer and life-support backpack allow the astronaut to live in space.

Vocabulary

Have the students use these words as part of your motivating discussion and in the follow-up *Space Lab* and *Space Countdown* activities.

- EVA (extravehicular activity: working outside the controlled environment of the space cabin)
- device (machine)
- modular (having separate self-contained parts)
- torso (body excluding head and limbs)
- kilometer (1,000 meters)
- Celsius (metric unit to measure temperature)
- urine
- insulating

Motivation

1. Why do we layer clothing?
(Layers of clothing keep us warm. It is fashionable. It makes us look attractive.)

2. Name some activities that might require the use of an oxygen backpack.
(Mountain climbing, scuba diving, deep-sea exploration.)

3. Why is a life-support system needed for these activities?
(A life-support system provides the amount of oxygen our bodies require.)

Activity Description

The *Student Liftoff* page for this lesson contains two activities: *Space Lab* and *Space Countdown*.

The *Space Lab* is a hands-on experiment that helps students to explore the effects of insulating materials on temperature. The students are asked: How do layers of material insulate? The experiment uses air and soil as insulating materials. You might want to extend this activity using other insulators, such as feathers or strips of newspaper. This activity may be done at school or at home.

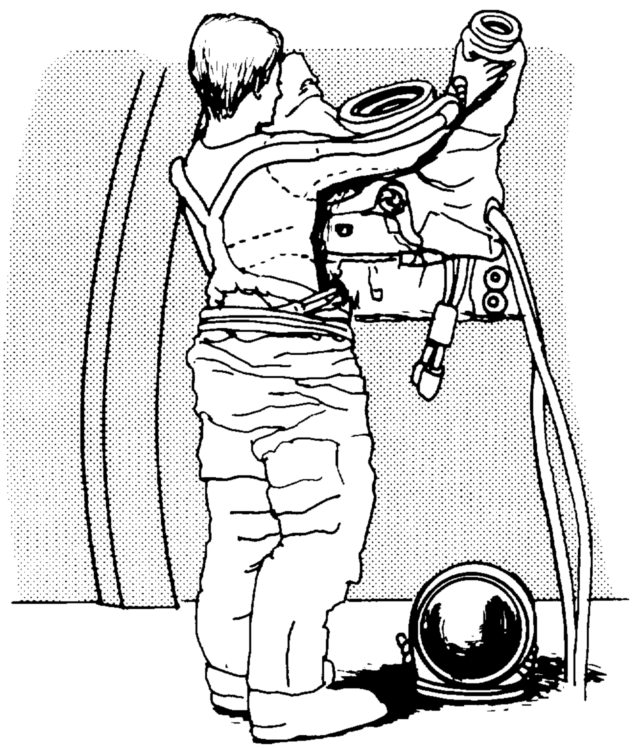
The *Space Countdown*, a math activity, uses addition, subtraction, multiplication, and division to find temperatures at different altitudes. (Answers: -6.4° C; -19.6° C; -29.5° C.)

Additional Activities for School or Home

- Simulate the bulkiness of the different layers that make up a space suit. Have the students put on several additional layers of clothing (pants, skirts, shirts, sweaters, gloves). Have them observe how difficult movement is. Discuss possible ways to make a "space suit" more comfortable.

- Place an oven mitt next to a source of heat. Observe that the outside of the mitt next to the heat becomes quite hot, while the inside that faces away from the heat stays cooler. Compare the protection provided by the oven mitt insulation to the protection our atmosphere provides for Earth from the heat of the Sun.

STUDENT LIFTOFF



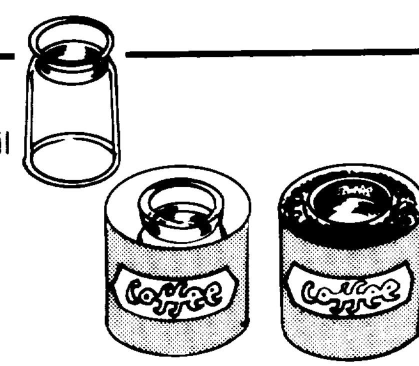
Have you ever worn long johns? Astronauts wear long johns under their space suits.

The first layer of an astronaut's extravehicular activity (EVA) gear consists of a specially designed pair of long johns and a urine-collecting device. The long johns also have plastic water-cooling tubes running through them. These tubes help keep the astronaut comfortable during work.

The second part of the space suit has several layers of protective and insulating materials. The torso, pants, arms, and gloves come in interchangeable sizes. These modular pieces can be put together to fit different astronauts on other missions.

The third part, the life-support system, is a backpack built in to the upper portion of the torso. The unit contains oxygen and electric power that will last for seven hours.

Space Lab



How do layers of material insulate?

You need: 3 small jars, 2 coffee cans, a thermometer, tap water, soil

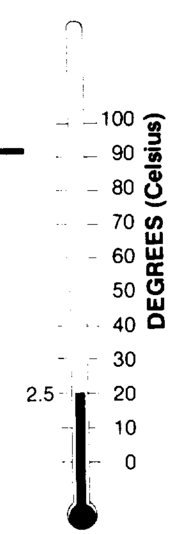
Step 1. Fill the 3 small jars with tap water.
Place one jar in one of the coffee cans.

Step 2. Place a second jar in the other coffee can.
Fill the space between the jar and this coffee can with soil.

Step 3. Place the cans in sunlight.
Measure and record the water temperatures after 1 hour, 4 hours, 24 hours.
Which water is warmest? Coolest?
Which provides better insulation: air or soil?
How is the soil like the material insulators of a space suit?

Space Countdown

Temperatures drop at approximately 6.6° C per kilometer as you go higher in the atmosphere. If the outside temperature is 20° C at 2.5 kilometers, what will it be at 6.5 kilometers? At 8.5 kilometers? At 10 kilometers?



TEACHER PRINTOUT

Objectives

Students will understand the following:

- The new Shuttle suit or extravehicular mobility unit is a self-contained life-support system.
- Space suits are manufactured in different sizes and are worn by both men and women.
- Two space suits are provided for each space mission.

Motivation

1. What kinds of sports clothing can be worn by both men and women?

(Blue jeans, shorts, T-shirts, sweat shirts, sweat pants, sweat socks, warm-up suits, headbands, wristbands, sun visors.)

2. What kinds of size labeling are used for clothing worn by both men and women?

(One size fits all. Small, medium, and large. Clothing sized in these ways is loose-fitting and is often made of materials that stretch.)

3. Why do doctors carry portable beepers?

(They can be reached when there is a problem. Relate to the built-in spacecraft computer that warns astronauts of problems.)

Vocabulary

Have the students use these words as part of your motivating discussion and in the follow-up *Space Lab* and *Space Countdown* activities.

- EMU (extravehicular mobility unit: the entire space suit assembly)
- pressure vessel (the part of the space suit that is filled with oxygen to maintain a steady pressure on the body)
- PLSS (Portable Life-Support System)
- milliliter
- purifier
- evaporation

Activity Description

The *Student Liftoff* page for this lesson contains two activities: *Space Lab* and *Space Countdown.*

The *Space Lab* is a hands-on experiment in which students observe the effects of evaporation on temperature. The students are asked: How do moving air and evaporation decrease temperature? This experiment helps the students to understand how moving air inside a space suit cools an astronaut. This activity may be done at school or at home.

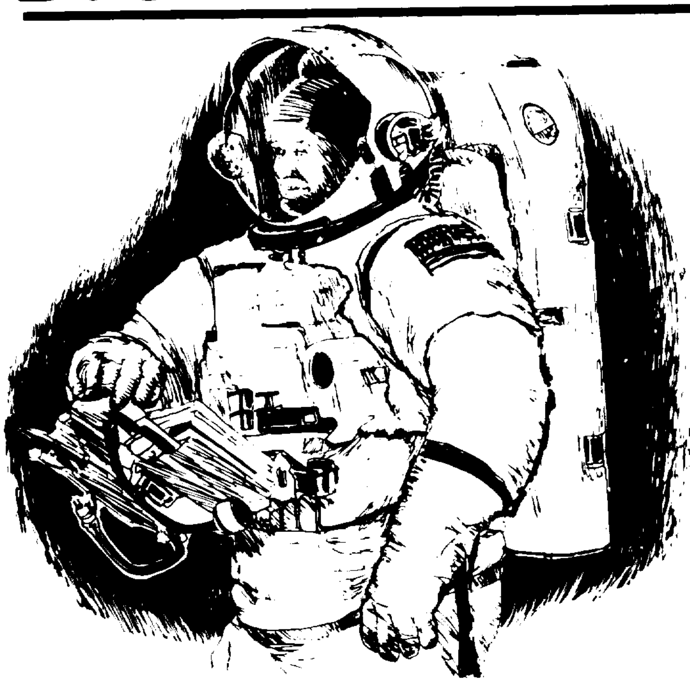
The *Space Countdown,* a math activity, requires the students to use metric measurements, to convert measurements from one unit to another, to use multipliction with decimal points, and to calculate percentages.

(Answers: 1. 184%; 2. 0.864 g, 1.59 g, 184%. The percentages are the same. Although the mass of objects in space are much less than their mass on the ground, the proportions remain constant.)

Additional Activities for School or Home

- Have students place thermometers under various types of insulating materials, such as asbestos, several layers of aluminum foil, or rubber. To heat the surfaces of the insulating materials, use different sources of heat, such as a heating pad, a hair dryer, a curling iron, a floodlight, or sunlight. Compare the results. Which insulation provides the best protection? Record the data in a table to show the results. You might want to suggest that students have an adult present while doing this experiment.
- Demonstrate the need for flexible joints in a space suit. Inflate long balloons to simulate the pressurized space suit. Try to bend the balloons as an astronaut might bend an elbow or a knee. Observe what happens.

STUDENT LIFTOFF



Small, medium, or large? Shuttle space suits come in many sizes and can be worn by men or women. On each flight, suits are provided for only two astronauts.

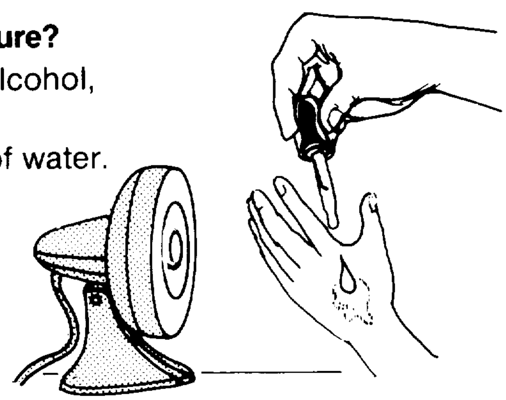
The new suit, called an extravehicular mobility unit (EMU) has three main parts: a liner, a pressure vessel, and a Portable Life-Support System (PLSS). The PLSS, part of a built-in backpack, supplies oxygen for breathing and suit pressurization and cleans carbon dioxide and odors from the air. A tiny built-in computer provides start-up instructions and warns the astronaut of problems.

There is even a water purifier, so drinking water can be sipped inside the helmet. The Shuttle space suit is a remarkable engineering feat.

Space Lab

How does moving air and evaporation decrease temperature?

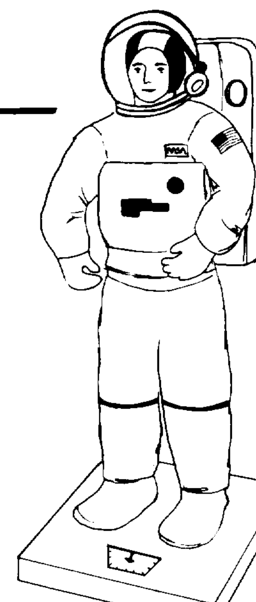
You need: 15 milliliters of water, 15 milliliters of rubbing alcohol, a small fan or other source of moving air



Step 1. Dampen the back of your hand with a few drops of water. Turn on the fan and let it blow across your hand. What do you feel?

Step 2. Repeat step 1, using the alcohol.
What do you feel now?
What happens to the water and the alcohol?
How does evaporation decrease temperature?
How does moving air in the space suit help an astronaut?

Space Countdown



While wearing an EMU in space flight, Astronaut Bruce McCandless has traveled outside the Shuttle. Fill in the blanks.

1. On Earth, Astronaut McCandless's mass is 86.4 kg. His EMU has a mass of 159 kg. The mass of the EMU equals__________percent of Astronaut McCandless's mass.
2. The effects of gravity while orbiting in the Shuttle are about 0.0001 as strong as the effects of gravity while standing stationary on the Earth's surface. In orbit, Astronaut McCandless's mass is__________g and his EMU has a mass of__________g. The mass of the EMU equals __________ percent of Astronaut McCandless's mass.

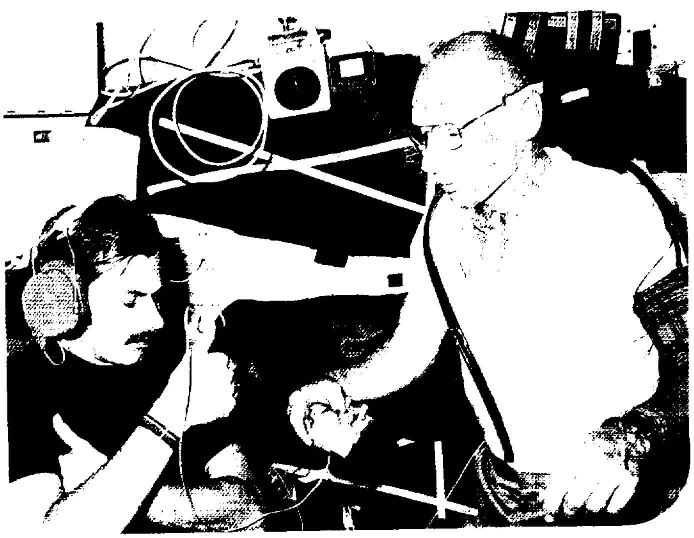
What can you say about both percentages? Why?

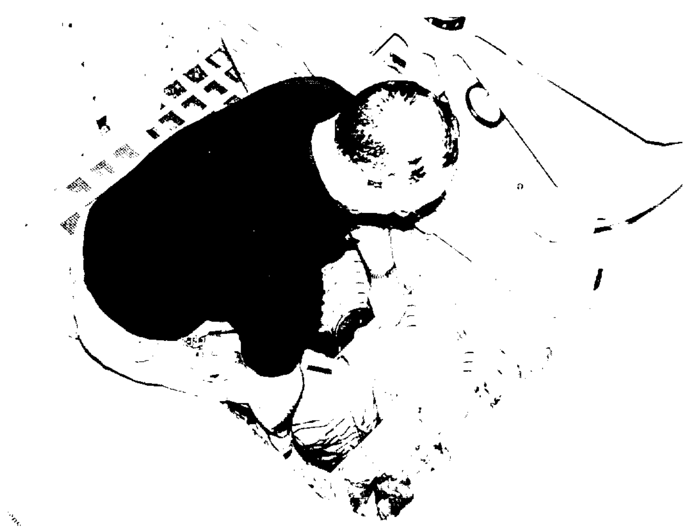
NOTES

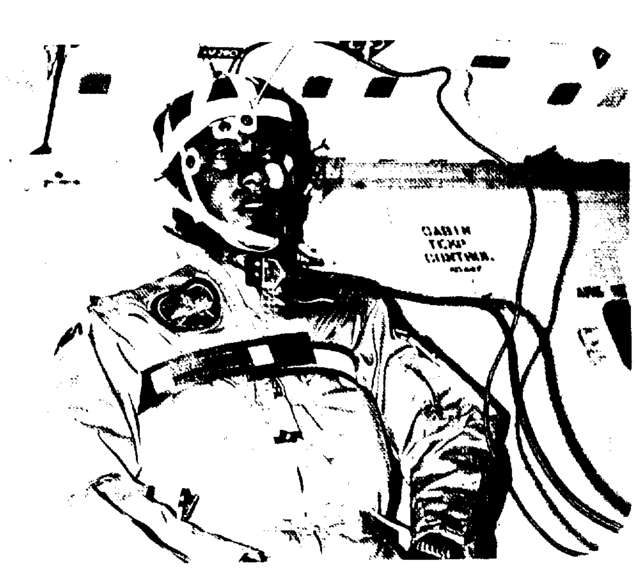
H E A L T H

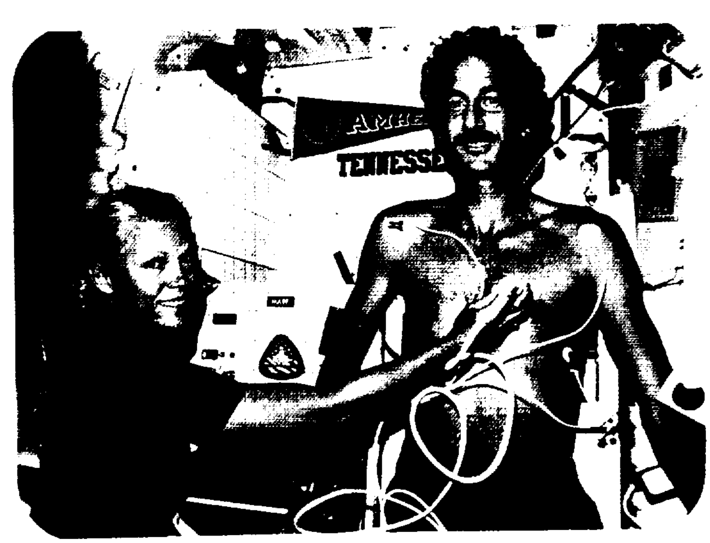
BOOK II

LIVING IN SPACE









BACKGROUND INFORMATION

Concepts

The health of astronauts aboard the Space Shuttle depends on

- a mission specialist who provides medical care
- shuttle supplies available in the Shuttle Orbiter Medical System (SOMS) kit
- proper waste management within the confines of the orbiter

Personal Hygiene

Showers do not work too well aboard the Space Shuttle because the water escapes and floats around in the air. Therefore, crew members take ten-minute sponge baths. For privacy, they draw a curtain from the bathroom door to the side of the galley. The bathroom has a recessed washbasin with warm water, a soap dispenser, a mirror, and a light. On the wall are clips to attach towels, washcloths, and other personal items. One cloth is used for washing, another for rinsing. Water and soapsuds stick to the skin in weightlessness, so little water is needed to wash. At the back of the basin, a fan pulls excess water into a drain.

The bathroom has a toilet, a light for reading, and even a window to look down at Earth. Weightlessness affects the use of the toilet. Crew members must use foot restraints, a seat belt, and handholds to remain seated. The toilet uses a fan to draw solid wastes to a compartment where they are dried and disinfected. This toilet can be used up to four times in an hour.

Mission Specialist Care

During a Space Shuttle mission, a mission specialist watches over the health of crew members. This person may be either a physician or an astronaut who has paramedic training. There is special medical equipment aboard for taking electrocardiograms, a medicine chest with first-aid kits, and medication to treat illnesses such as sinus congestion or insomnia. On past missions, many astronauts suffered from motion sickness, with symptoms of dizziness, nausea, cold sweats, headaches, and drowsiness. Although there is a drug to prevent motion sickness, many space travelers prefer not to take it. Motion sickness usually lasts about three days. Should serious medical problems arise, the mission specialist aboard the Shuttle can consult with a doctor who is always available at Mission Control in Houston.

Shuttle Orbiter Medical System

The three-part Shuttle Orbiter Medical System (SOMS) kit aboard the Space Shuttle helps the mission specialist treat both simple and serious illnesses. One part of the medical emergency kit has a stethoscope, a blood pressure cuff, sutures, disposable thermometers, and medicines that can be injected. The second part of the kit contains adhesive tape, gauze bandages, Band-Aids, and a variety of oral medicines. The third, an instrumentation pack, has a respirator, an intravenous fluid system, and a defibrillator.

Waste Management

Keeping clean and disposing of garbage is important aboard the Shuttle. Space studies show that microbes can multiply rapidly in a small weightless area such as a spacecraft cabin. Rapid germ growth could endanger the health of everyone on board. To avoid this problem, the food preparation, dining, toilet, and sleeping areas are cleaned regularly. Clothing that has been worn is sealed in airtight plastic bags and stored in lockers beneath the mid-deck living area. After meals, crew members put empty food containers into trash bags, which are then sealed and stored in lockers. Reusable eating utensils and trays are cleaned with germicidal wet wipes.

TEACHER PRINTOUT

Objectives

Students will understand the following:

- The health of the astronauts is monitored by a mission specialist.
- The mission specialist is either a doctor or an astronaut with paramedic training.
- The mission specialist has medicine available to relieve common problems caused by being in space.

Vocabulary

Have students use these words as part of your motivating discussion and in the follow-up *Space Lab* and *Space Countdown* activities.

- paramedic training (training that prepares a person to stand in for a doctor)
- mission specialist (scientist responsible for experimental data and housekeeping)
- motion sickness (nausea caused by the effect of certain movements on the inner ear)
- disorientation (a state of having lost one's sense of direction)

Motivation

1. What might cause motion sickness?
(Different types of transportation, such as cars, boats, trains, or planes. Rides in amusement parks that flip you over, spin you around, or move very quickly.)

2. Why is there someone with medical training aboard the Space Shuttle?
(To help out in an emergency. To take care of sick or injured astronauts. To understand the information provided by a doctor at Mission Control.)

3. What common types of illnesses or medical emergencies might occur on a Shuttle mission?
(Crew members get bruises or cuts from working with the equipment. They might become dizzy, nauseous, or have difficulty sleeping.)

Activity Description

The *Student Liftoff* page for this lesson contains two activities: *Space Lab* and *Space Countdown.*

The *Space Lab* is a hands-on experiment that allows students to discover how our sense of sight helps us know direction. The students are asked: How does motion cause disorientation? The experiment uses a blindfold and a spinning swivel chair to cause disorientation. This type of chair can usually be found in the nurse's or principal's office. This activity may be done at school or at home.

The *Space Countdown,* a math activity, requires the students to read and understand information, plot coordinates, and create a line graph.

Additional Activities for School or Home

- Have a student sit in a swivel chair facing forward, with head erect. Rotate the chair slowly for thirty seconds. Ask other students to observe the seated student's eye movements. Repeat the rotation and have the seated students toss a ball into a wastepaper basket placed 1.5 meters away. What happens?
- Have the students research the training and job of a paramedic. Interview a paramedic who works as part of an ambulance team in the community. Some questions to include in an interview might be: Why did you become a paramedic? What problems do you have in your work? What experiences make you feel most needed?

STUDENT LIFTOFF

Feeling sick? How do you get a doctor in space?

Either a doctor or an astronaut with paramedic training is on board the Space Shuttle to take care of the astronauts. This mission specialist can give medicine to astronauts who are suffering from motion sickness. The medicine relieves feelings of nausea, dizziness, headache, and drowsiness. Other medicines are available for a stuffy nose or for not being able to sleep.

The mission specialist can talk with a doctor at Mission Control at all times. They can consult about injuries and illnesses. The astronauts can always depend upon the mission specialists.

Space Lab

How does motion cause disorientation?

You need: a swivel chair, a blindfold, a pencil, a friend

Step 1. Ask a friend to sit in a swivel chair and put on a blindfold. The friend places arms out in front of the body, holding a pencil in an upright position.

Step 2. Ask your friend to point the pencil in the direction of rotation as you turn the chair.
Slowly stop the chair. Then turn the chair in the opposite direction. Watch the pencil.

Step 3. Stop the chair. Watch the pencil.
In what direction did your friend point the pencil after the first rotation?
When the chair was stopped? After the second rotation?
How do our senses help orient us in space?

Space Countdown

Astronaut John had motion sickness during the space flight.
John felt very sick on Tuesday, Wednesday, and Friday.
John felt a little better on Thursday.
John felt well on Monday, Saturday and Sunday.

Plot the points on the line graph to show how astronaut John felt each day.

	M	Tu	W	Th	F	Sa	Su
VERY SICK							
A LITTLE BETTER							
WELL							

TEACHER PRINTOUT

Objectives

Students will understand the following:

- The Shuttle Orbiter Medical System (SOMS) is a three-part medical kit.
- The medical kit contains instruments, medication, and equipment.
- The SOMS enables the mission specialist to care for both minor and major medical problems.

Vocabulary

Have the students use these words as part of your motivating discussion and in the follow-up *Space Lab* and *Space Countdown* activities.

- suture (thread or wire used to join cut or torn tissue)
- insomnia (sleeplessness)
- blood pressure (the pressure of the blood on the walls of the arteries)
- circulatory problem (difficulty with the movement of blood through the body)
- stethoscope

Motivation

1. When might emergency medical care be needed?
(If you hurt yourself on the playground or in class. When you participate in sports. If you have an accident.)

2. What type of equipment does a doctor keep in a medical bag?
(Stethoscope; blood pressure cuff; instruments to examine the eyes, nose, throat, and ears; medicine; and syringes for giving injections.)

3. What does a doctor do to help a patient?
(Call in another doctor. Order special tests. Put the patient into the hospital for observation.)

Activity Description

The *Student Liftoff* page for this lesson contains two activities: *Space Lab* and *Space Countdown.*

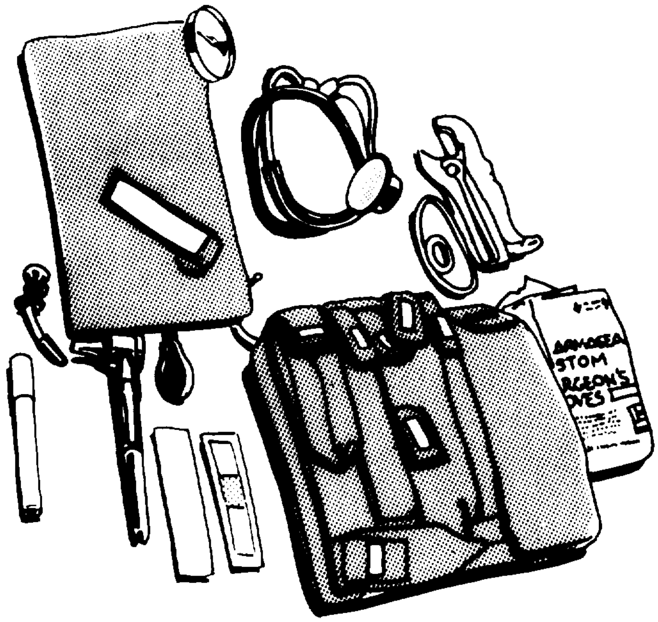
The *Space Lab* is a hands-on experiment that allows students to work with a nurse as a resource person. The students are asked: How does activity affect blood pressure? Students learn to take a person's blood pressure using a blood pressure cuff and a stethoscope. This activity may be done at school or at home.

The *Space Countdown,* a math activity, requires the students to read a chart, subtract using decimals, find the average temperature, and make a line graph. You might wish to review how to draw a line graph and also provide graph paper for students. (Answers: Temperature differences from day to day are +.9° C; -1.0° C; +.4° C; +.4° C; -1.7° C; -.3° C; average is 38.2° C.)

Additional Activities for School or Home

- Have the students sit cross-legged on the floor, with their hands clasped behind their heads, with elbows extended. Note two observations: first, the length of time students can remain in this position; and second, the number of times students must shift their bodies to be comfortable. Discuss attitudes and feelings as well as physical discomfort.
- Brainstorm emergencies that could arise on a class trip. What types of instruments, medications, and equipment would be needed to help care for the injured? Design an emergency travel kit that could be used on class trips.

STUDENT LIFTOFF



"Ever ready and ever prepared" should be the motto for medical treatment aboard the Space Shuttle. The Shuttle Orbiter Medical System (SOMS) is a three-part medical kit. This eight-kilogram kit is stored in the mid-deck area.

The emergency medical pack has a stethoscope, a blood pressure cuff, sutures, and disposable thermometers. Band-Aids, gauze bandages, tape, and medicines for stuffy noses or insomnia are stored in another pack. The third pack contains equipment to help with lung, heart, or circulatory problems.

The SOMS allows the mission specialist doctor to care for minor illnesses and to be prepared for major medical problems. The astronauts feel safe with their "hospital" in space.

Space Lab

How does activity affect blood pressure?

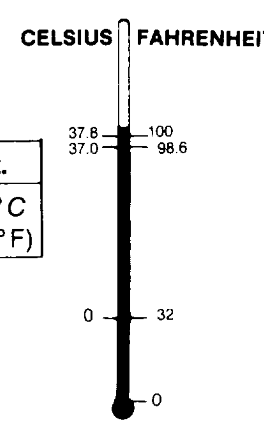
You need: a blood pressure cuff, a stethoscope, a friend, a nurse

Step 1. Have your friend sit quietly for thirty seconds. Have the nurse show you how to use a blood pressure cuff and a stethoscope to measure blood pressure. Record the results. Remove the cuff.

Step 2. Have your friend do thirty jumping jacks. Repeat step 1 on your own. What happened to your friend's blood pressure?

Space Countdown

An astronaut was sick for one week during training.
The chart shows the sick astronaut's daily body temperatures in both Celsius and Fahrenheit units.



DAYS

	Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
Temperature	38.3° *C* (*101°* F)	39.2° *C* (*102.5°* F)	38.2° *C* (*100.8°* F)	38.6° *C* (*101.4°* F)	39.0° *C* (*102.2°* F)	37.3° *C* (*99.3°* F)	37.0° *C* (*98.6°* F)

1. What is the difference in Celsius temperature from day to day?
2. What is the average Celsius temperature?
3. Draw a line graph to show the temperature changes.

TEACHER PRINTOUT

Objectives

Students will understand the following:

- Waste management is important in the limited area of the Space Shuttle cabin.
- Garbage and trash are sealed in airtight plastic bags.
- Living areas are cleaned regularly to maintain a healthy environment.

Vocabulary

Have the students use these words as part of your motivating discussion and in the follow-up *Space Lab* and *Space Countdown* activities.

- environment (surroundings, especially as they affect living conditions)
- utensils (forks, knives, spoons)
- stow (place or arrange compactly)
- disinfectant (substance used to destroy harmful germs)
- waste management

Motivation

1. Why do people put garbage in plastic bags?
(To prevent unpleasant odors. To prevent leakage. To prevent stray animals from eating the garbage.)

2. What happens during a garbage strike?
(Garbage collects, overflows the pails, and piles up in the streets. Restaurants and offices have no place to store the garbage.)

3. What do you and your family do to keep germs out of your house?
(Use cleaning and disinfecting products in bathrooms and kitchens. Wash floors, sinks, tubs, and toilets frequently.)

Activity Description

The *Student Liftoff* page for this lesson contains two activities: *Space Lab* and *Space Countdown*.

The *Space Lab* is a hands-on experiment that allows students to observe the growth of germs in sterile nutrient agar by exposing the agar to the air. The students are asked: How do disinfectants help prevent the growth of germs? They then test two disinfectants. This activity may be done at school or at home. *NOTE: Be sure to tape agar dishes closed after exposure. Do not allow students to open these dishes. Germs may be present.*

The *Space Countdown*, a math activity, requires students to solve a problem using multiplication and decimal division. Students compare results and formulate a conclusion.
Answers:
Company A: 1920, .029; Company B: 1800, .027.

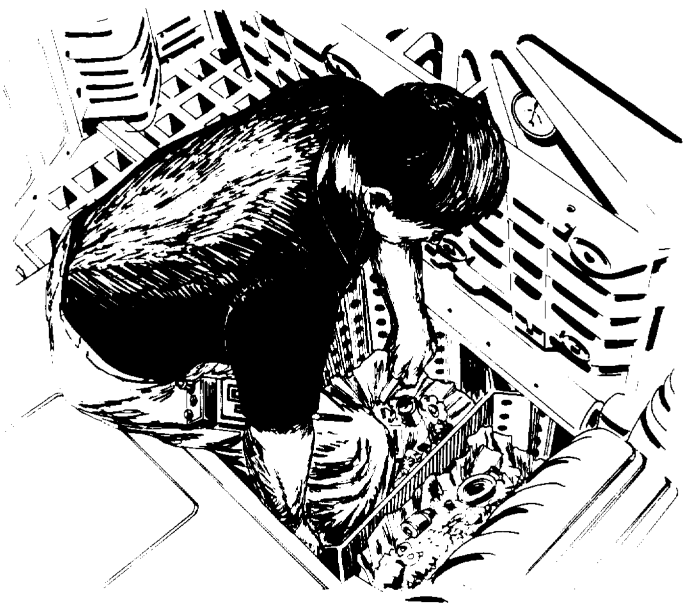
Company B offers the best buy.

Additional Activities for School or Home

- Disposing of garbage has become a major problem in many communities. Have a classroom discussion about garbage disposal at your school. You might want to invite your school custodian to answer the students' questions about the quantity and types of waste products. Divide the class into committees to set up their own school waste-management system. Consider waste and recycling.

- Draft a letter to the National Aeronautics and Space Aministration (NASA) persuading them to buy plastic garbage bags for waste disposal from your company.

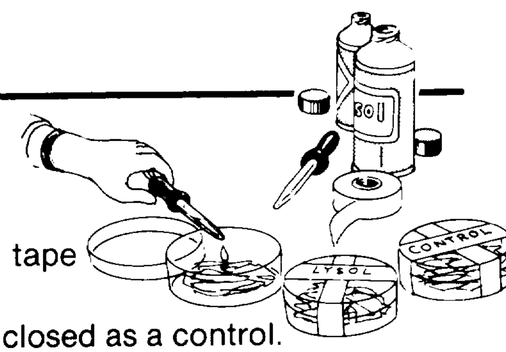
STUDENT LIFTOFF



Where would you stow seven days' accumulation of garbage?

Aboard the Space Shuttle, garbage and trash are stowed in a locker until landing. Disposing of waste materials is important in the limited cabin area. Germs can grow rapidly in the weightlessness of space and create a health hazard. To maintain a healthy environment, crew members clean the living areas regularly. People aboard the Shuttle put on clean trousers weekly, clean shirts every three days, and clean underwear everyday. The Shuttle crew makes sure that food containers and leftovers are sealed in bags, and utensils and trays are cleaned with wet wipes before they are reused. Wet trash and garbage are stowed in a locker beneath the mid-deck floor. The Shuttle crew has waste management under control.

Space Lab



You may need an adult to help you with this experiment.

How do disinfectants help prevent the growth of germs?

You need: three petri dishes with sterile nutrient agar, two disinfectants (such as Lysol and Pine-Sol), an eyedropper, tape

Step 1. Remove the covers from two of the agar dishes.
Expose them to the air for one hour. Leave the third dish closed as a control.

Step 2. After one hour, add ten drops of one disinfectant to one of the dishes.
Label it. Repeat with the second disinfectant.
Recover and tape dishes closed. Observe for the next three days.
What happens to each of the dishes?
What are the effects of the disinfectants?

Space Countdown

Two companies submitted bids for plastic bags for garbage disposal aboard the Space Shuttle.

Company A offered cartons of 32 boxes with 60 plastic bags per box at a cost of $57.00.

Company B offered cartons of 40 boxes with 45 plastic bags per box at $50.00.

Which company offered the best buy?

ORIGINAL PAGE IS
OF POOR QUALITY

NOTES

H O U S I N G

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B O O K II

LIVING IN SPACE

BACKGROUND INFORMATION

Concepts

The Space Shuttle is a working delivery system for satellites. Crew members work

- on the flight deck, the Shuttle's control center
- in the cargo bay, which carries free-flying payloads and attached payloads
- in Spacelab, a completely furnished laboratory that remains in the Shuttle cargo bay

Flight Deck

The flight deck, which is the upper section of the Space Shuttle cabin, contains the flight controls and crew stations for launch, orbit, payload handling, and landing. The commander and the pilot sit in forward-facing seats. During launch and reentry, the mission specialists and payload specialists sit either behind the commander and pilot or in the mid-deck area.

Payload displays and controls in the back of the flight deck make up the aft crew station. From here, crew members can maneuver the spacecraft, operate the manipulator arm, and monitor payloads. The area has two overhead windows and two windows on the aft bulkhead for looking into the cargo bay. At the first station, the mission specialist uses a computer keyboard and spacecraft system monitors to manage the flight. On the back wall are the pilot's and payload handler's stations. On the side opposite the mission specialist, the payload specialist monitors each payload. Variable-height work platforms allow crew members to work comfortably.

Spacelab

Spacelab, the billion-dollar science and technology laboratory, is history's largest international space project. Built by ten European countries working with the European Space Agency, Spacelab fits into the cargo bay of the Space Shuttle.

For the United States, Spacelab extends the Shuttle's research capabilities. For the Europeans, Spacelab provides an entry into manned space flight without their having to start their own program. Because of this program, many of the nonastronaut scientists, engineers, and payload specialists working in Spacelab will be European.

Modular Design

Although Spacelab is an attached payload, it is part of the Space Transportation System (STS). Like many other STS components, Spacelab is made of self-contained segments or modules. Because of this modular design, Spacelab can accommodate a variety of scientific missions. Two major subsections of Spacelab are cylindrical crew modules, and U-shaped unpressurized instrument-carrying pallets. Crew modules and pallets are combined in many ways to suit each mission.

In a crew module, a normal atmosphere is maintained. The kind of equipment found in the crew module depends on the particular mission. There can be mice or monkeys in cages, heaters to create new alloys or crystals in microgravity, or data-recording devices and computers. The pallets are used to carry instruments for experiments that need direct exposure to space.

The pallets are open cargo containers that hold telescopes, radiation counters, and Earth-sensing equipment. One pallet can hold up to 2,700 kilograms of equipment. The controls for pallet-mounted experiments are in the crew module and are therefore protected from temperature extremes in space.

Scientists and engineers from all around the world work together in Spacelab.

Cargo Bay

The cargo bay is located in the center of the Shuttle's fuselage. Here, both free-flying and attached payloads are stowed for their trip into space. Support hardware, such as launch cradles and environmental-control equipment, also travels in the cargo bay. This large part of the Shuttle, 18 meters long and 4.5 meters in diameter, has enough space to hold one and a half school buses. Cargo bay doors must remain open while the Shuttle is in orbit to avoid excessive heat buildup, which would force a landing after only a few hours in space.

TEACHER PRINTOUT

Objectives

Students will understand the following

- The flight deck is the control center of the Space Shuttle.
- The commander, the pilot, the mission specialist, and the payload specialist work on the flight deck.
- The aft crew station has the controls to manage the orbiter and its payload.

Vocabulary

Have the students use these words as part of your motivating discussion and in the follow-up *Space Lab* and *Space Countdown* activities.

- aft crew station (area at the back of the flight deck)
- payload (cargo)
- manipulator arm (a piece of equipment in the cargo bay that can lift heavy weights, such as satellites)
- wraparound windows
- orbiter
- maneuver

Motivation

1. What is the control center of your school?
(The main office, for the principal, assistant principal, secretary, typist, and nurse. The area where you can get information about the running of the school.)

2. How is an airplane controlled?
(The pilot and the co-pilot share responsibility for flying the plane and staying in contact with airport control towers.)

3. What other forms of transportation have control centers?
(Trains can be controlled by computer. Buses and taxis are controlled by dispatchers. Planes and ships can be controlled by radar.)

Activity Description

The *Student Liftoff* page for this lesson contains two activities: *Space Lab* and *Space Countdown*.

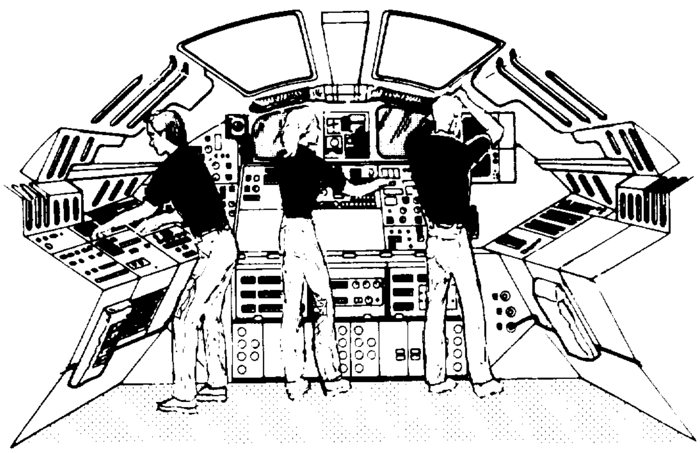
The *Space Lab* is a hands-on activity that helps students understand the value of following step-by-step instructions. The students are asked: How does it help to follow directions step by step? The activity results in the creation of original cassette programs. This activity may be done at school or at home.

The *Space Countdown*, a math activity, requires that the students follow step-by-step directions shown in flowchart patterns to solve problems. Students add, subtract, and multiply.
(Answers: 0, 2, answer can vary.)

Additional Activities for School or Home

- Have a student committee set up a control center for scheduling different playground activities for one week. Poll other class or grade members to choose the activities. Plan the playground areas to be used. Schedule students for each activity on a rotating basis.
- Have one child sit in the middle of a circle and put on clothes by following minutely explicit directions given by the group. The child in the middle must do exactly what the group says. To start off this activity, choose a student who will follow directions.

STUDENT LIFTOFF



Looking for the control center aboard the Space Shuttle?

Try the flight deck. Here is where the flight is controlled and the payloads are handled. The flight deck has two sets of controls for the commander and the pilot, four seats, and wraparound windows.

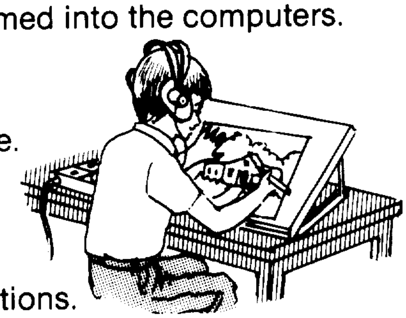
Controls in the back of the flight deck make up the aft crew station. The mission specialist uses a computer keyboard and system monitors to manage the flight. The payload specialist controls each payload and operates the manipulator arm and the television system. The pilot maneuvers the orbiter for docking or payload handling. Launch, orbit, and landing are controlled by the crew working together on the flight deck.

Space Lab

Directions for work aboard the Space Shuttle are preprogrammed into the computers.

How does it help to follow directions step by step?

You need: tape recorder, earphones, a blank cassette, a friend



Step 1. Write out step-by-step instructions for drawing a house. Record the instructions on the blank cassette.

Step 2. Play the cassette and follow your own instructions. Are the instructions clear? Easy to follow?

Step 3. Have a friend listen to your tape and follow the instructions. In what way did your instructions help your friend complete the drawing?

Space Countdown

Follow the flowchart directions to solve the problems.

Write 24. → Add 16. → Subtract 40. → Name the number

Name the number one greater than 11. → Add the number one less than 9. → Subtract the sum of 6 and 12. → Name the number.

Think of a number. → Double it. → Add 100. → Name the number.

TEACHER PRINTOUT

Objectives

Students will understand the following:

- The cargo bay carries free-flying payloads and attached payloads.
- Cargo bay doors must remain open during orbit to permit cabin heat to dissipate.
- Astronauts enter the cargo bay through an air lock and tunnel.

Vocabulary

Have the students use these words as part of your motivating discussion and in the follow-up *Space Lab* and *Space Countdown* activities.

- cargo bay (the large main body of the Shuttle where the payload is stored)
- air lock (two hatches with space in between)
- payload support hardware (equipment, such as launch cradles, needed to work with the payload)
- Spacelab (an orbiting laboratory)
- free-flying payload
- attached payload

Motivation

1. Why do we use moving vans?
(Vans move our belongings, such as furniture, household items, and clothing, from one place to another.)

2. Why do people pay different amounts of money to move their belongings?
(You can be charged according to the mileage from one place to another. You can be charged by how many things you send. You can be charged by volume or by weight.)

3. Why do you open your door or window on a warm day?
(To let the warm air out. To let a breeze blow in. To get fresh air moving around in the house.)

Activity Description

The *Student Liftoff* page for this lesson contains two activities: *Space Lab* and *Space Countdown*.

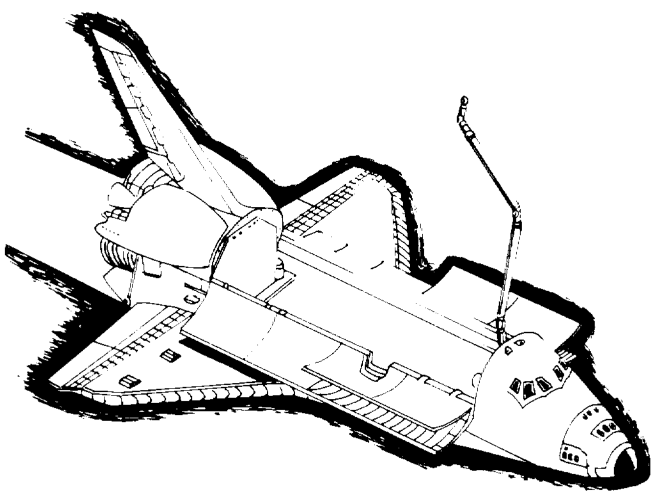
The *Space Lab* is a hands-on experiment that demonstrates how payloads traveling in space require special protective packaging. The students are asked: How do you package a payload to protect it on landing? The students' ingenuity is challenged in packaging an egg so that it will withstand impact. This activity may be done at school or at home.

The *Space Countdown*, a math activity, requires the students to read a chart, add and subtract decimals, and calculate additional distance and speed. (Answers: Distance 9.8 m; Fastest in last second; 4th — 34.3, 39.2; 5th — 41.1, 49.0; 6th — 53.9, 58.8.)

Additional Activities for School or Home

- Have students research the size of an average Earth-orbiting satellite (with solar panels closed for launch). Use the following information to answer the question. The payload cargo bay of the Shuttle is 4.6 meters in diameter and 18.3 meters long. How many satellites will fit into the cargo bay? (Hint: Students must find volume.)
- The Space Telescope carried aboard the Space Shuttle will be able to see ten times as far as Earth-based telescope. Find a large, clear place on the school playground. Place a small object on the ground. Have students walk away until they can no longer see the object. Measure the distance. Get a map of the buildings in your community. Ask students which buildings they could see if their vision were magnified ten times.

STUDENT LIFTOFF



The cargo bay, which is reached through an air lock and a tunnel, is large enough to hold one and a half school buses. When in orbit, the two curved cargo bay doors must stay open. If the doors remain closed, cabin heat will build up, forcing a landing after only a few hours.

Many different payloads are carried in the cargo bay. Free-flying payloads, such as satellites and the Space Telescope, are released to fly alone. Attached payloads, such as Spacelab, remain in the cargo bay throughout the mission. The cargo bay also carries payload-support hardware, such as launch cradles. Everything stored in the cargo bay must be weighed.

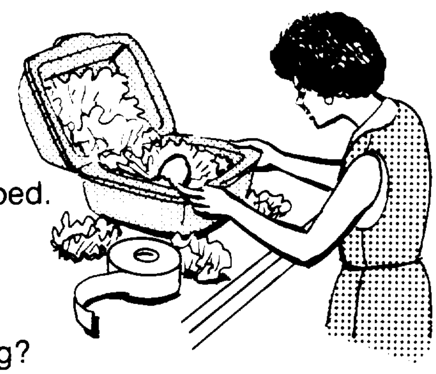
Before reentry, cargo bay door latches must be closed.

Space Lab

You will need an adult to help you with this experiment.

How do you package a payload to protect it on landing?

You need: a fast-food hamburger Styrofoam container, a raw egg, protective packaging materials of your own choice



Step 1. Design a container that will protect an egg when it is dropped.

Step 2. Secure the egg in its container.

Step 3. Drop the egg from the highest available place; for example, a second-story window.
How do different kinds of payload packaging affect the egg?

Space Countdown

How much does the distance increase each second?
When is the object traveling the fastest?

FALLING EGGS AND GRAVITY

Time	Distance	Speed
1st Second	4.9 meters	9.8 meters per second
2nd Second	14.7 meters	19.6 meters per second
3rd Second	24.5 meters	29.4 meters per second
4th Second		
5th Second		
6th Second		

Fill in the distance and speed for the 4th, 5th, and 6th seconds.

TEACHER PRINTOUT

Objectives

Students will understand the following:

- Spacelab is a completely furnished laboratory that remains in the Space Shuttle cargo bay.
- Spacelab has a modular design consisting of crew modules and pallets.
- Crew modules provide an environment similar to a laboratory on Earth.

Vocabulary

Have the students use these words as part of your motivating discussion and in the follow-up *Space Lab* and *Space Countdown* activities.

- module (self-contained unit forming part of a spacecraft)
- vacuum (empty space)
- crystals (particles with a definite repeating pattern)
- pallet (open cargo container)
- financed
- pressurized
- laboratory

Motivation

1. What would you find in a science laboratory?
(You might find test tubes, microscopes, chemicals, laboratory animals such as rats, mice, and guinea pigs, and any other science equipment.)

2. Why would scientists want to work in space?
(They would be interested in performing experiments in a weightless environment. Scientists are always curious and questioning about new situations.)

3. What kinds of experiments would you design to be performed in Spacelab?
(Accept any reasonable and supportable answers.)

Activity Description

The *Student Liftoff* page for this lesson contains two activities: *Space Lab* and *Space Countdown*.

The *Space Lab* is a hands-on experiment that is similar to crystal experiments that have been performed in Spacelab aboard the Space Shuttle. The students are asked: How do crystals grow? By using a piece of string to seed a solution of dissolved salt, students create an environment suitable for crystal formation. This activity may be done at school or at home.

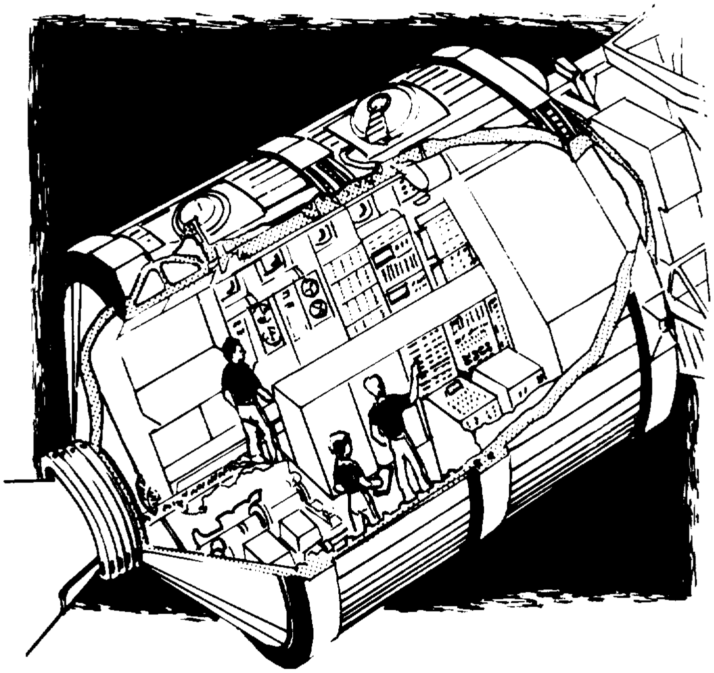
The *Space Countdown*, a math activity, requires the students to use a formula, V=lwh, to measure the volume of three given figures and complete a chart. You may wish to review this concept before students work on their own. (Answers: A=4, 2, 3, 24; B=4, 5, 2, 40; C=3, 6, 3, 54.)

Additional Activities for School or Home

- The Space Telescope carried aboard the Space Shuttle will be able to see ten times as far as Earth-based telescopes. Find a large, clear place on the school playground. Place a small object on the ground. Have students walk away until they can no longer see the object. Measure the distance. Get a map of the buildings in your community. Ask students which buildings they could see if their vision were magnified ten times.

- Discuss the advantages of making Spacelab available to private companies and nonastronaut scientists. Can you think of any disadvantages?

STUDENT LIFTOFF



Where can you find a flying laboratory? Look in the cargo bay aboard the Space Shuttle.

Spacelab is a completely furnished laboratory, financed and built by the European Space Agency.

Spacelab has modules and pallets that can be assembled in various ways for each mission. Crew modules provide a shirt-sleeve environment where payload specialists work on experiments, produce materials such as crystals, and make observations. A pressurized tunnel connects the crew module to the orbiter mid-deck. The pallets are outdoor units used for experiments performed in the vacuum of space. To make removal of module experiments easy and quick, Spacelab equipment is mounted on racks.

Spacelab is a perfect laboratory for scientific missions in space.

Space Lab

How do crystals grow?

You need: 250 milliliters of warm water, two drinking glasses, salt, a spoon, a fifteen-centimeter piece of string, a pencil

Step 1. Pour the 250 milliliters of warm water into a glass. Put some salt into the warm water. Stir until the salt dissolves. Add salt until no more will dissolve. (Some undissolved salt will remain at the bottom of the glass.)

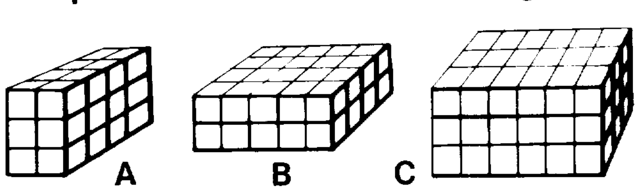
Step 2. Now pour the clear water into another glass. (Leave the undissolved salt in the first glass.) Tie a piece of string around the pencil. Lay the pencil across the top of the glass. The string should hang down into the water.

Step 3. Place the glass in a protected place. Check weekly. How long does it take for the first crystals to form? Check daily. What do you observe?

Space Countdown

The amount of space inside a closed surface is called its volume.
Volume is measured in cubic units.
The formula is *Volume = length times width times height* ($V=lwh$).

Complete the table for these three figures.



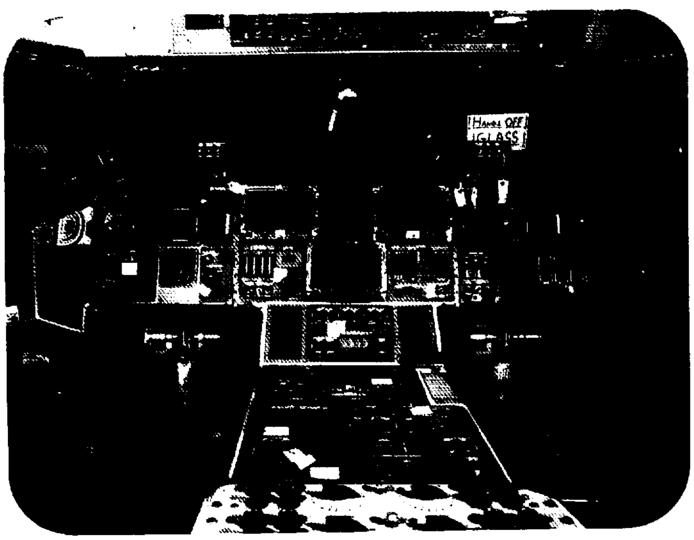
	A	B	C
How many cubic units long?	4	?	?
How many cubic units wide?	?	5	?
How many cubic units high?	?	?	?
Volume in cubic units.	?	?	?

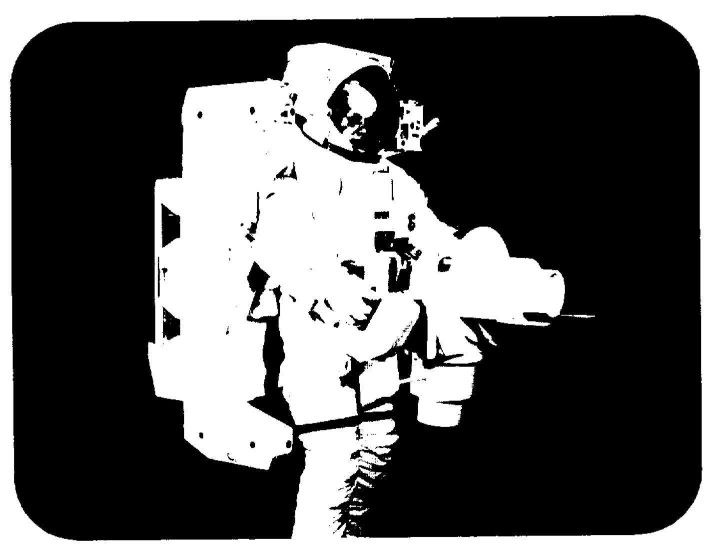
NOTES

COMMUNICATION

BOOK II

LIVING IN SPACE





BACKGROUND INFORMATION

Concepts

Communication connects the whole world. The Space Shuttle is the delivery and service system for communications satellites. In space, communication is

- controlled by computers
- essential for a successful mission
- accomplished easily and quickly across great distances because of communications satellites

Mission Communication

During a space mission, communication between crew members in different parts of the Shuttle is vital. One type of communication equipment is a simple headset with a microphone, earphone, control unit, and clip. The unit connects to eight intercom terminals in the crew compartment and also permits communication with ground control. The unit has five available channels, two for air-to-ground, one for air-to-air, and two for intercom. Two of these audio terminal units (ATU) have built-in speaker/microphones for use without the headset. Television cameras and a teleprinter complete the onboard communication package.

Communications Satellites

Communications satellites have been used since 1960 when Echo I, a huge Mylar balloon, circled Earth in an orbit 240 kilometers high. In 1962, Telstar, the first active communications satellite, was rocketed into orbit 4,800 kilometers above Earth. The newest communications satellites are in a geosynchronous orbit 35,680 kilometers above Earth. These satellites travel at the same speed as Earth rotates, and thus they are always above the same location on Earth. Communications satellites use microwaves to send signals across space. Microwaves are straight-line signals that form a line of sight from the point of broadcast. Signals travel further when they are relayed from antenna to antenna. A communications satellite could be thought of as an unusually tall antenna with a very long line of sight.

Delivery and Service System

The Space Shuttle is a reusable cargo ship which can carry four small satellites or two large satellites in its cargo bay. The Shuttle delivers and launches communications satellites for private companies and for the United States government.

The Space Shuttle crew can repair satellites that need servicing. They can pick up damaged satellites and return them to Earth. Because it is less expensive to launch a satellite from the Shuttle than from a rocket, Shuttle cargo space for communications satellites is reserved many years in advance.

Computers and Communication

Computers direct almost every maneuver made by the Space Shuttle. These directions are printed on two mass-memory tapes, providing thirty-four million types of information. The information is loaded into the computer before launch. Then the computers are sealed so the information cannot be erased accidentally. Five onboard computers handle all the data processing for the mission. These computers check each other's data a few hundred times every second. The data processing system translates signals to and from the orbiter systems and sensors into computer language. The system displays what is happening and allows crew members to interact with the system. Even though the computer keyboard has only thirty-two buttons, astronauts can enter commands or ask more than a thousand questions. The Shuttle computer program is divided into nine major parts, each with a number of operational sequences. The computers control the basic running of the spacecraft, continually check the flight path, process medical data from the crew, and monitor the livability and air content of the Shuttle. Computer programs are written in what is known as high-order assembly language/Shuttle (HAL/S). The Shuttle's computer system is in complete control of every phase of the flight.

TEACHER PRINTOUT

Objectives

Students will understand the following:

- Computers handle the data needed for each flight.
- There are four main computers and one backup computer.
- Computers control every phase of a space mission.

Vocabulary

Have the students use these words as part of your motivating discussion and in the follow-up *Space Lab* and *Space Countdown* activities.

- mass-memory tapes (tapes providing thirty-four million types of information)
- preprogrammed (information fed into a computer prior to launch)
- plotting points (locating points on a grid, using x and y coordinates)
- data
- computer
- launch
- orbit

Motivation

1. What are some ways to save information for future use?
(Information can be saved by writing it down. It can be taped on a recorder. It can be told to a friend. It can be drawn. Information can be put on film.)

2. How do computers help people?
(Computers can work quickly. They are accurate. They can do tedious and repetitive jobs that would be boring for people. They store large amounts of information.)

3. What is the automatic pilot on an airplane?
(The automatic pilot is a preprogrammed computer system capable of flying the plane when the pilot must do something else or when the pilot is tired.)

Activity Description

The *Student Liftoff* page for this lesson contains two activities: *Space Lab* and *Space Countdown*.

The *Space Lab* is a hands-on activity that shows how the binary number system works. Students are asked: How does a computer operate? The activity simulates the on/off switching of a computer. You may wish to review the concept of base ten and other number bases. This activity may be done at school or at home.

The *Space Countdown*, a math activity, requires the student to plot points on a grid, thus simulating the way a computer draws. You may wish to review horizontal and vertical axes.

Additional Activities for School or Home

- Visit a local post office to see how computers are used for sorting small sacks and parcels.
- Research the use of computers in everyday life. Find pictures that show how and where computers are used. Create collages that demonstrate the use of computers in medicine, business, school, the home, and entertainment.
- Make up a space code, using numbers in place of letters. Share your code with a friend. Transmit and receive messages in code. Decode the message.

STUDENT LIFTOFF

Do you need information quickly? Ask the computers on board the Space Shuttle. Five computers handle the data needed for each flight. They use two preprogrammed mass-memory tapes. The computer program divides the flight into nine major parts.

The computers carry out a prelaunch check. They send data to the engines during launch and orbit. Information on the Shuttle's performance is recorded by the computers. Four main computers and one backup computer process information at the same time. When it comes to making decisions, the computers compare results, vote, and the losing computer is ignored.

The pilot enters commands on the computer keyboard to guide the Space Shuttle during reentry into Earth's atmosphere. Computers control every phase of the mission.

Space Lab

How does a computer operate?

You need: 4 pieces of cardboard measuring 15 by 23 centimeters each, a black marker, a friend

Step 1. The computer number system uses two digits, 0 and 1.
Write 0 on one side of each piece of cardboard, and write 1 on the other side.
Stand the cardboard pieces on the chalk rail.

Step 2. Above each cardboard, write the place value.
The number 7 in base 2 is shown on the diagram.

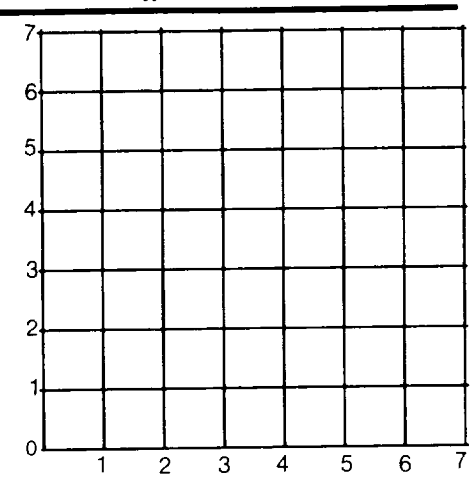
Step 3. Have a friend tell you a number in our number system (base 10)
Show the number in base 2, using the cardboard pieces.
How does this show the way a computer operates?

Space Countdown

People can draw with computers by plotting points on a grid. Every command has two numbers. The first number tells the computer how far across the grid to move. The second number tells the computer how far up the grid to move.

Plot the following points on the grid:

(2,0)	(3,4)	(7,3)
(2,1)	(4,5)	(7,2)
(2,2)	(5,5)	(7,1)
(2,3)	(6,4)	(7,0)



TEACHER PRINTOUT

Objectives

Students will understand the following:

- Communication is essential for a successful mission.
- There is communication between a spacewalker, crew members, and Mission Control.
- Power for space walk communication is in the backpack.

Motivation

1. Why is it important for people on a committee to communicate with each other?
(To help each other. To plan and organize the responsibility of each person. To understand the assignment clearly.)

2. How do CB radios help travelers?
(Travelers can get road information from other people. They can get help if their car breaks down. They have someone to talk with.)

3. Why do we use antennas on radios and television sets?
(They help us to hear better. They provide a clearer picture. They pick up signals for better reception.)

Vocabulary

Have the students use these words as part of your motivating discussion and in the follow-up *Space Lab* and *Space Countdown* activities.

- spacewalker (an astronaut involved in an extravehicular activity)
- backpack (part of an astronaut's Primary Life-Support System, attached to the upper torso of the space suit)
- walkie-talkie (a set of radio transmitters)
- Mission Control (the control base on Earth)
- communication • Snoopy hat

Activity Description

The *Student Liftoff* page for this lesson contains two activities; *Space Lab* and *Space Countdown*.

The *Space Lab* is a hands-on experiment that demonstrates one way in which people can communicate. Students are asked: How does an astronaut spacewalker communicate? This lab uses walkie-talkies to simulate astronaut communication. If walkie-talkies are not available, have students make their own out of tin cans and string. This activity may be done at school or at home.

The *Space Countdown,* a math activity, has the student use a hand-held calculator to perform division with large numbers. The calculator is used as a substitute computer. The students will chart their time and accuracy. (Answers: **1.** 21.130434; **2.** 24.083333; **3.** 10.303797; **4.** 3.1798715; **5.** 11.190293.)

Additional Activities for School or Home

- Imagine you are on a space walk. Write and dramatize a series of communication sequences between yourself and Mission Control.
- Research the history of American space walks. Develop a time line that shows each space walk and what was accomplished.
- Make a communication assembly carrier (Snoopy hat). Use a baseball cap or bathing cap, plastic tubing, Styrofoam earphones, and flexible plastic straws. Be creative.

STUDENT LIFTOFF

Space walk — space talk. Communication among a spacewalker, the other crew members, and Mission Control is essential for a successful mission. An astronaut spacewalker wears a snug-fitting Snoopy hat made up of a microphone and earphones. The communication unit is worn under the space helmet and operates without the use of hands. Power for the Snoopy hat is located in the astronaut's backpack.

Radios for space walk communication are also in the backpack, and they receive their power from the pack itself. These radios have antennas that fit on top of the packs. Throughout the mission, the radios provide information about the astronaut's health. The information is sent to the Shuttle as well as to the doctors at Mission Control in Houston.

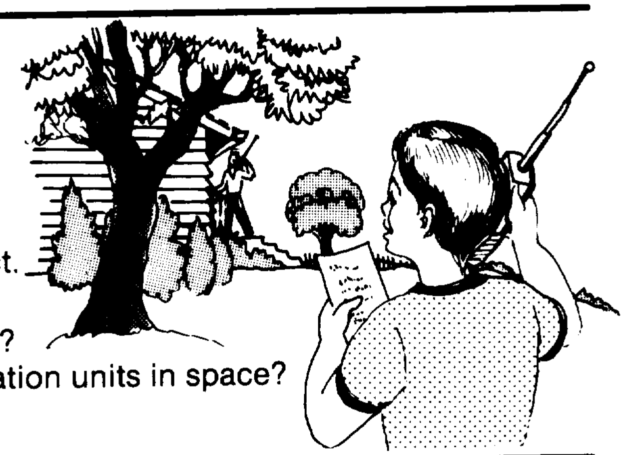
Space Lab

How does an astronaut spacewalker communicate?

You need: a friend, a pair of walkie-talkies

Step 1. Write out a message to send to your friend.
Give your friend one of the walkie-talkies.
Take the second walkie-talkie and go outside.

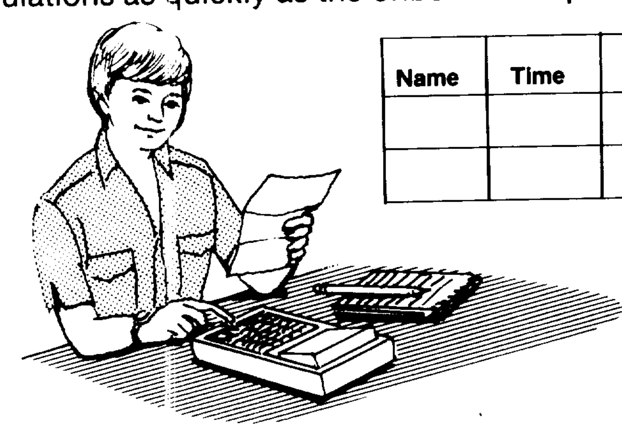
Step 2. Turn on the walkie-talkies. Activate voice contact.
Send your message.
Why must an astronaut be able to communicate?
How are walkie-talkies similar to the communication units in space?



Space Countdown

Try to make the following space calculations as quickly as the onboard computers can.
Use a calculator as your computer.
Chart your time and accuracy.

1. 486÷23
2. 289÷12
3. 814÷79
4. 1485÷467
5. 8762÷783



Name	Time	Number Correct

TEACHER PRINTOUT

Objectives

Students will understand the following:

- Communications satellites connect most of the world.
- The Space Shuttle is used to deliver, launch, and service communications satellites.
- Communications satellites operate with short radio wave signals, called microwaves.

Vocabulary

Have the students use these words as part of your motivating discussion and in the follow-up *Space Lab* and *Space Countdown* activities.

- geosynchronous orbit (an orbit 35,680 kilometers from Earth, in which a satellite travels at the same speed as Earth rotates, so that the satellite is always above the same location on Earth)
- telemetry (sending information from a satellite to Earth)
- microwaves (very short radio waves)
- satellites
- pi (π = 3.14)

Motivation

1. What is the meaning of the word satellite?
(A satellite is an object that orbits another object in space. Our Moon is a satellite.)

2. What are artificial satellites?
(Man-made satellites that orbit Earth.)

3. How have communications satellites helped us?
(They make it easier to send messages. They carry television and radio programs from places that are far away. There is less interference with signals in space than on Earth. They have improved international telephone service.)

Activity Description

The *Student Liftoff* page for this lesson contains two activities: *Space Lab* and *Space Countdown.*

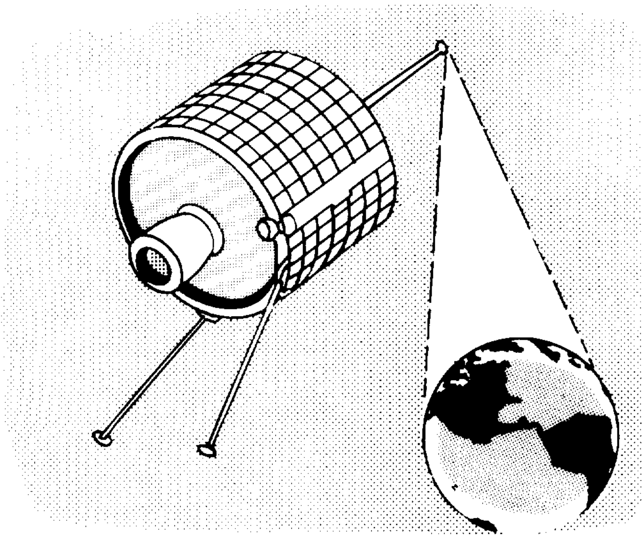
The *Space Lab* is a hands-on experiment that demonstrates how signals are sent and received. The students are asked: How do relay satellites send signals back to Earth? A mirror is used to represent the relay satellite in orbit.

The *Space Countdown,* a math activity, requires the students to use multi-step procedures to solve problems. Students use pi and the formula $C = \pi D$. (Answers: 242,408 km in one orbit; 484,816 km in two orbits; 10,100.3 km per hour.)

Additional Activities for School or Home

- This activity simulates what happens when radio signals from a satellite cannot reach Earth. Attach a small portable radio to the end of a meter stick. Tune in to a local station, using normal volume. Hold the stick by the unattached end at arm's length. Slowly turn in place so the radio makes a complete orbit. Observe the change in volume as the radio moves. What causes this change?
- Set up two teams. Debate whether the federal government or private industry should control and operate communications satellites. Have each team do as much research as possible.

STUDENT PRINTOUT



Do you want to keep in touch? Use a communications satellite in space orbit. These satellites transmit radio and television programs worldwide. They connect computers from everywhere to other computers. Satellites receive, process, and send huge amounts of data.

The Space Shuttle is the delivery and service system for communications satellites. Launched from the Shuttle, the satellites are positioned in a geosynchronous orbit, 35,700 kilometers above Earth. At that height, three communications satellites can transmit signals anywhere in the world. The Shuttle itself uses the Tracking and Data Relay Satellite System (TDRSS).

Communications satellites operate with short radio wave signals called microwaves. Transmission of these radio waves back to Earth is called telemetry. Satellites send signals quickly, shrinking distances everywhere.

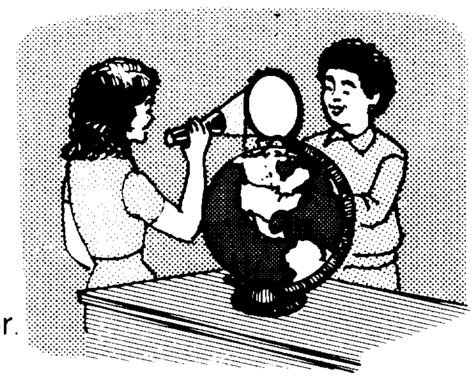
Space Lab

How do relay satellites send signals back to Earth?

You need: a flashlight, a mirror, a globe, a friend

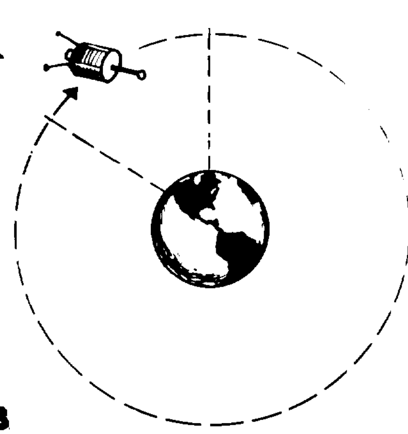
Step 1. Darken the room. Hold the flashlight at a spot on the globe (Earth).
Have a friend hold the mirror away from the globe.
What is the purpose of the flashlight?
What is the purpose of the mirror?

Step 2. Turn on the flashlight. Aim it at the "relay satellite" mirror.
Which spot on "Earth" received the signal? Why?



Space Countdown

A communications satellite travels in geosynchronous orbit every twenty-four hours at an altitude of 35,700 kilometers above Earth.
Earth's diameter (D) is 5,800 kilometers.
The formula for circumference (C) is $C = \pi D$. $\pi = 3.14$.
How many kilometers does a satellite travel in one orbit? Two orbits?
What is the speed in kilometers per hour at which the satellite travels?

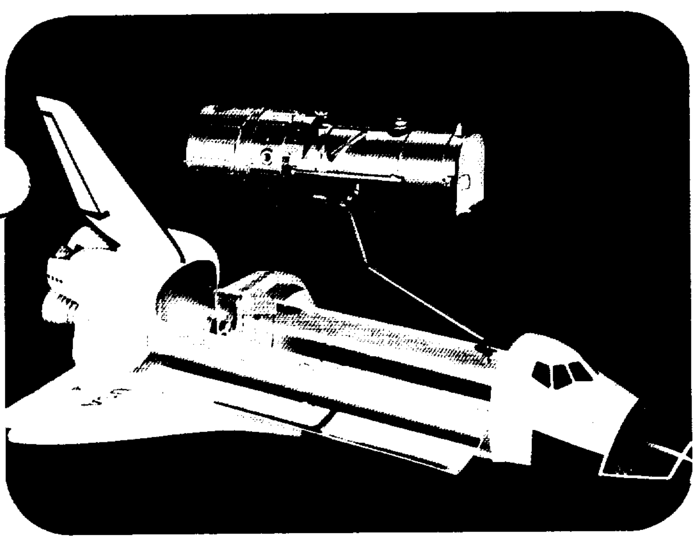


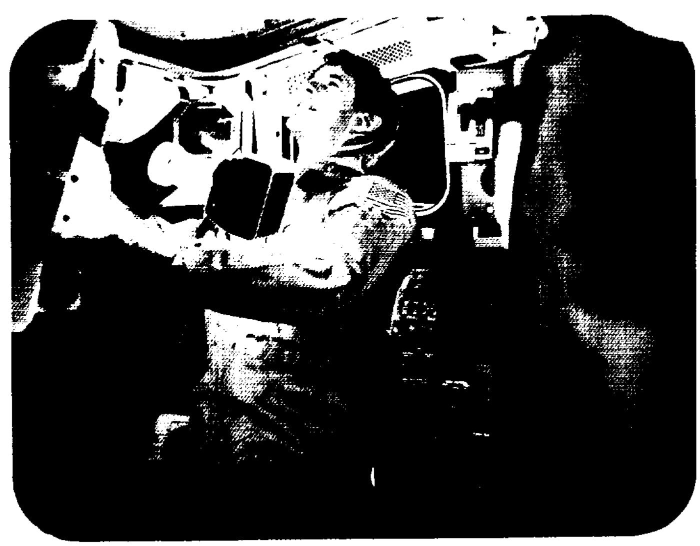
NOTES

W O R K I N G

B O O K II

LIVING IN SPACE





BACKGROUND INFORMATION

Concepts

The Space Shuttle, a reusable spacecraft, functions as a delivery system, a repair shop, and a science lab. On Space Shuttle missions, astronauts

- play interactive roles
- are helped in their work by a manipulator arm
- work in space, using extravehicular gear

Working in Space

The Space Shuttle is sometimes called a space workhorse because of the great variety of jobs it can perform in orbit. The Shuttle is first of all a freighter, delivering and launching satellites into space and bringing some back to Earth in the cargo bay. The orbiter is also a repair shop for damaged orbiting satellites.

Shuttle-launched satellites can monitor the oceans, the air, the weather, and Earth's resources. Other satellites provide data-relay services, including television, radio, general communications and computer information.

The cargo bay of the Shuttle provides a microgravity environment for life-science studies relating to humans, other animals, and plants. In addition, the cargo bay serves as a science research laboratory for space experiments and observations, and as a factory for manufacturing products such as metal alloys and perfect crystals.

Interactive Crew Roles

All crew members aboard the Shuttle — commander, pilot, mission specialist, and payload specialist — have specific responsibilities. Yet at the same time they work cooperatively. Control of the spacecraft and mission management are in the hands of astronauts. Payload supervision is in the hands of a nonastronaut scientist, engineer, or physician, called a payload specialist. These specialists, often selected by the organizations that have built the payloads, are also trained in housekeeping chores and emergency flight procedures.

Remote Manipulator System

As part of NASA's continuing effort to involve other nations in the American aerospace research program, a Remote Manipulator System (RMS) was designed, developed, and built by Canadian industrial firms. This work was directed and funded by the National Research Council of Canda. The RMS is a robotlike metal arm used by the astronauts to move satellites in and out of cargo bay. This 15.2-meter space crane has three movable joints: shoulder, elbow and wrist. Attached to the wrist is the end effector, which has a three-wing capture mechanism for gripping the standard docking target on all free-flying payloads. The RMS can be operated manually or automatically. In the manual mode, an astronaut controls the arm from the flight deck. The devices used look like the controllers on home video games. In the automatic mode, tasks are keyed into the computer and then the RMS performs each task.

The manipulator arm helps astronauts carry out their scheduled activities. Working in the weightlessness of space, astronauts must use great amounts of energy. The manipulator arm conserves astronaut energy.

Extravehicular Activity

Astronauts wear protective space suits when they work in the cargo bay or outside the Shuttle. A manned maneuvering unit is used for flying in space. This hand-controlled propulsive device allows an astronaut to reach free-flying satellites and to transport cargo of moderate size. Extravehicular tasks range from cleaning optical surfaces to deploying, retracting, and positioning antennas and solar panels.

In the near future, the Space Shuttle will deliver modules for living and working in space. Astronauts will use these modules to construct a permanent space operations center in low Earth orbit.

TEACHER PRINTOUT

Objectives

Students will understand the following:

- The basic Shuttle crew consists of a commander, a pilot, a mission specialist, and a payload specialist.
- Each crew member has a specific job.
- Astronauts have interactive roles.

Vocabulary

Have the students use these words as part of your motivating discussion and in the follow-up *Space Lab* and *Space Countdown* activities.

- mission specialist (scientist responsible for experimental data and housekeeping)
- payload specialist (nonastronaut scientist working on a specific experiment)
- alloy (mixture of two or more metals)
- payload (cargo)
- commander
- pilot

Motivation

1. What does teamwork mean to you?
(Getting along with a group, working together toward a common goal, cooperating, listening to others, and trying someone else's ideas.)

2. Why is it important for team members to do their own jobs?
(The success of the team depends on each member. No one wants to do someone else's work. Each person can help a team in a different way.)

3. What makes a championship team?
(A group that has trained and practiced together. A group that works together until they reach their goal.)

Activity Description

The *Student Liftoff* page for this lesson contains two activities: *Space Lab* and *Space Countdown*.

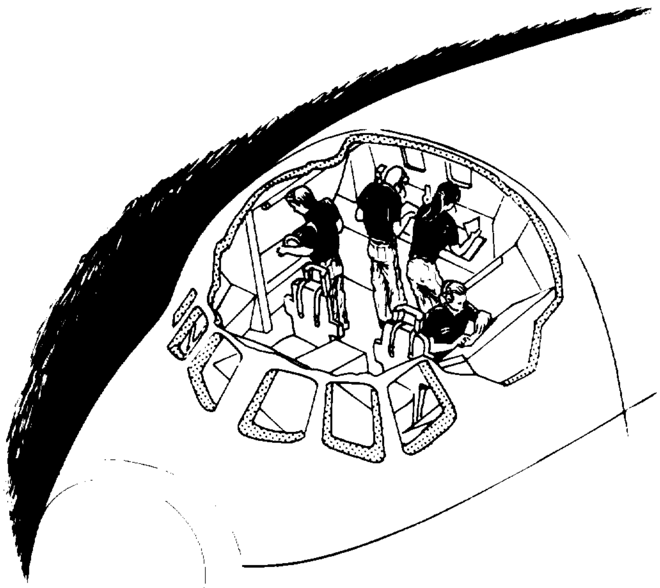
The *Space Lab* is a hands-on experiment in which students put together an electrical circuit. The students are asked: How do you use a power supply to create an electrical current? A dry cell, flashlight bulbs, and wire are used to do this experiment. This activity may be done at school or at home.

The *Space Countdown,* a math activity, requires the students to multiply and divide decimals and whole numbers. (Answers: 4 kilograms of copper; 7.5 kilograms of copper; 120 kilograms of alloy.)

Additional Activities for School or Home

- Have students analyze the problem of planning a space flight with astronauts from different cultures. Choose an activity that different people might do differently, such as using chopsticks or a fork for eating. Discuss the advantages and disadvantages of each method, trying to reach a compromise that will be comfortable for people from both cultures.
- Set up committees of five to seven students. Present each committee with the following problem to solve in thirty minutes: Your team is shipwrecked on an island. What three things would your team choose to return to civilization? Explain your plan. Have students emphasize the need for cooperation and teamwork.

STUDENT LIFTOFF



A Space Shuttle crew is like a championship basketball team. Each crew member has special duties to perform. The basic crew is a commander, a pilot, and a mission specialist. The commander and the pilot are in charge of the flight. The mission specialist coordinates payload operations and carries out the scientific objectives of the mission.

Each mission also has payload specialists who are scientists, engineers, or physicians. They are selected by the companies who build the payloads. The astronaut mission specialist and the scientist payload specialist work together on different kinds of experiments, such as producing metal alloys and crystals. These specialists also place satellites in orbit and capture satellites for return to Earth.

The success of a Space Shuttle mission requires a joint effort by the entire crew.

Space Lab

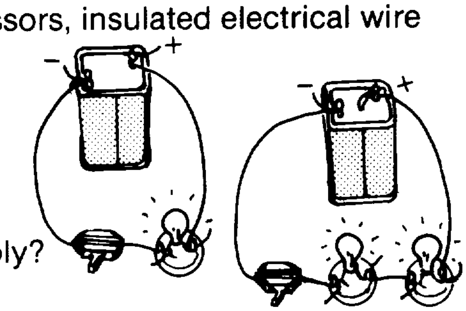
A 10- to 100-watt power supply operates the instruments aboard the Space Shuttle.

How do you use a power supply to create an electrical circuit?

You need: a dry cell, two flashlight bulbs in sockets, a switch, scissors, insulated electrical wire

Step 1. Connect the dry cell, one bulb in a socket, and the switch, to make a current. Turn the switch on and off. Observe what happens.

Step 2. Add a second bulb in a socket to the circuit. Turn the switch on and off. Observe. What happens now? What spacecraft instruments use an electrical power supply?



Space Countdown

Payload specialists experiment with metal alloys aboard the Shuttle. If .5 kilograms of copper are needed to make 10 kilograms of a copper-aluminum alloy, how many kilograms of copper are needed to make 80 kilograms of the alloy? 150 kilograms of the alloy?

How many kilograms of the alloy can be made from 6 kilograms of copper?

TEACHER PRINTOUT

Objectives

Students willl understand the following:

- The Remote Manipulator System (RMS) helps astronauts do their work.
- The system is a mechanical arm with shoulder, elbow, and wrist joints.
- The manipulator arm is operated from the flight deck by remote control.

Motivation

1. What machines make our work easier?
(All household appliances. Simple machines, such as levers, pulleys, wheels, and axles. Motors, elevators, escalators, pencil sharpeners.)

2. What is the advantage of using remote control?
(It is easier and more convenient to change television channels, play certain games, help sick people in hospitals.)

3. What kind of work can a mechanical arm do that would be dangerous for a human arm?
(Any work that involves excessive heat or cold; for example, factory work, working with fire, working in a steel mill, defusing bombs, or working with dangerous chemicals.)

Vocabulary

Have the students use these words as part of your motivating discussion and in the follow-up *Space Lab* and *Space Countdown* activities.

- remote control (guided from a distance)
- Earth-oriented (positioned toward Earth)
- mission specialist (scientist responsible for experimental data and housekeeping)
- deploy (place in orbit)
- remote manipulator system
- disabled
- electromagnet

Activity Description

The *Student Liftoff* page for this lesson contains two activities: *Space Lab* and *Space Countdown.*

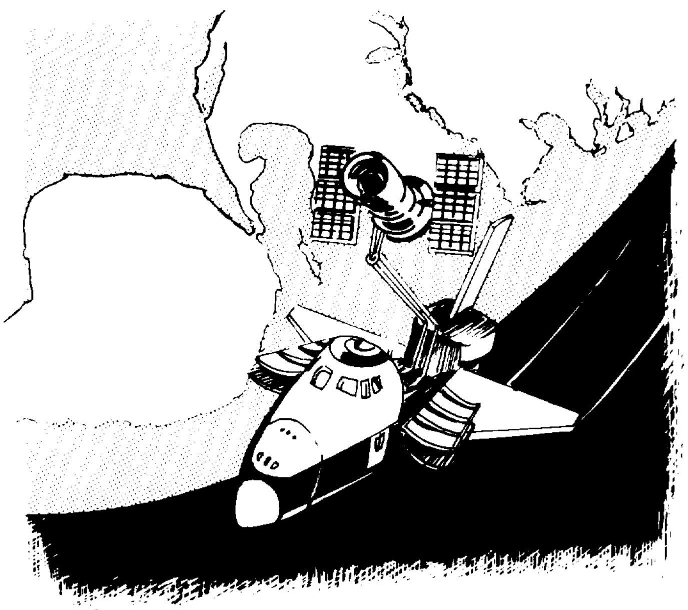
The *Space Lab* is a hands-on experiment using a student-made electromagnet. The students are asked: How can a satellite detect a magnetic field? Students explore the idea of satellites and the kinds of work they do. This activity may be done at school or at home.

The *Space Countdown,* a math activity, requires the students to multiply, divide, and use two steps to solve problems. (Answers: one tank will take 25 hours; two tanks will take 50 hours; seven-day mission will produce 504 kilograms of water.

Additional Activities for School or Home

- Have the students list utensils or tools found in their homes that increase their muscle power. For example, a screwdriver or a twist-off bottle opener. Students should experiment with these tools. Each student should bring one tool to class to demonstrate how it extends muscle power.
- Place the following materials in a bag: string, tape, scissors, cardboard tubes, brass fasteners, 2 sheets of 9-by-12 construction paper, Styrofoam hamburger trays, straws. You need one bag for each group of students. Have students design and create their own working version of a manipulator arm.

STUDENT LIFTOFF

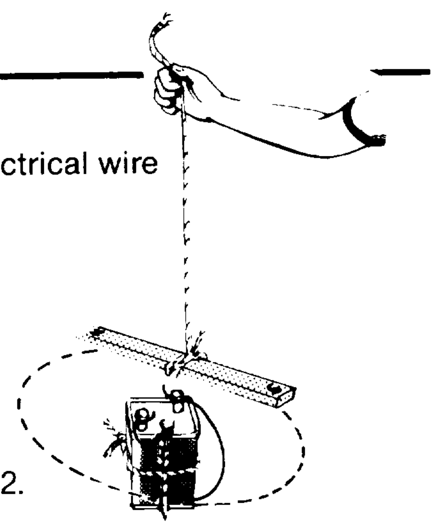


Need help lifting satellites out of the cargo bay? Let the remote manipulator arm do the job for you. The remote manipulator system is a mechanical arm with joints at the shoulder, elbow, and wrist. It is operated by six electrical motors and maneuvered from the flight deck by remote control.

To avoid damaging the orbiter or the payload, television cameras on the lower arm help the mission specialist guide the arm. The arm can deploy new satellites and capture satellites in need of repair. In the future, the arm may be used to rescue the crew from a disabled orbiter or to help build structures in space.

The manipulator arm is a valuable extension of human muscle and brain power.

Space Lab



How can a satellite detect a magnetic field?

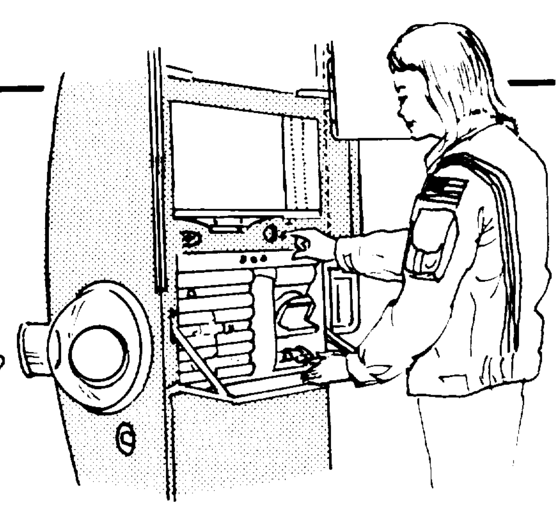
You need: a bar magnet, a large nail, a dry cell, string, insulated electrical wire

Step 1. Wrap several turns of wire around the nail.
Use some string to tie the nail (electromagnet) to the side of the dry cell. Tie another piece of string around the middle of the bar magnet.

Step 2. Hold the bar magnet by the string so it will swing freely around the dry cell. Observe.
Which way does the bar magnet face?

Step 3. Connect the ends of the wire to the dry cell. Repeat step 2.
What happens?
What other kinds of work can a satellite do?

Space Countdown



Electrical power for the Shuttle is generated by fuel cells, and water is produced as a by-product.
The water is used to drink, rehydrate food, and wash.
Each hour, 3 kilograms of water are produced.
How long does it take to fill one tank that can hold 75 kilograms of water? Two tanks?
How much water is produced during a seven-day mission?

WORKING LIVING IN SPACE

TEACHER PRINTOUT

Objectives

Students will understand the following:

- Astronauts use manned maneuvering units to move about in space.
- Astronauts perform a variety of extravehicular jobs.
- Astronauts wear space suits to work outside the Shuttle.

Vocabulary

Have the students use these words as part of your motivating discussion and in the follow-up *Space Lab* and *Space Countdown* activities.

- extravehicular activity (work performed outside the Shuttle)
- manned maneuvering unit (a self-contained backpack that attaches to the space suit)
- modular (having self-contained units)
- propelled
- cargo
- payload

Motivation

1. How would your life be different if you were able to fly?
(You could get from place to place very fast. You would never get caught in a traffic jam. You would not need someone to take you to other places.)

2. What kind of work could be done more easily if people could fly?
(Washing windows on tall buildings would be easier. Fixing outdoor electrical wires would be less dangerous. Trimming trees, painting bridges, constructing skyscrapers would all be easier.)

3. What types of clothing do you wear that protect you?
(Hats, coats, and boots protect us from rain. Winter coats, snowsuits, and gloves protect us from cold. Thermal underwear, shoes, sports equipment also protect us.)

Activity Description

The *Student Liftoff* page for this lesson contains two activities: *Space Lab* and *Space Countdown*.

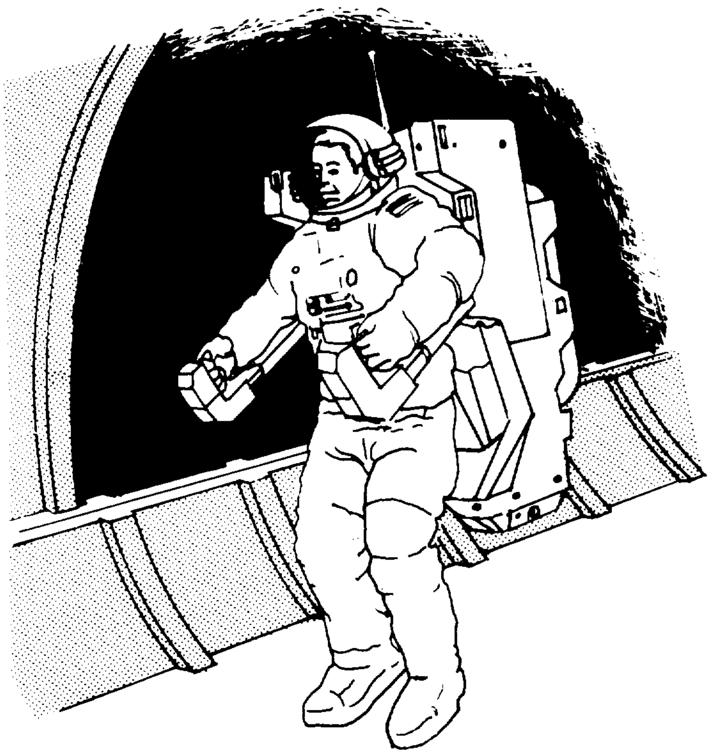
The *Space Lab* is a hands-on experiment demonstrating the insulating qualities of certain materials. The students are asked: How does a space suit protect an astronaut during extravehicular activity? Students become aware that proper insulation can protect against temperature extremes. This activity may be done at school or at home.

The *Space Countdown*, a math activity, requires the students to calculate fractional parts of metals contained in a micrometeorite. Students use subtraction and multiplication and change fractions to decimals. (Answers: An 8 gram micrometeorite has 3 grams of iron and 5 grams of nickel. A 6 gram micrometeorite has 3.6 grams of iron and 2.4 grams of nickel.)

Additional Activities for School or Home

- Astronauts wear space suits to protect them from dangers in space, such as micrometeorites. Have your students demonstrate the penetrating power of an object of small mass but high velocity. Hold a raw potato in one hand *(CAUTION: hand should not be behind potato).* With a quick, sharp motion, stab the potato with a soda straw. Try a slower motion and compare results.
- Have students work in pairs to make a crossword puzzle using words from the *Student Liftoff* page. Exchange puzzles with classmates and solve.
- Have students make a chart and list the activities they do in one day. Use one column to check activities that could only be done by a person. Use another column to check activities that could be done by a person, by a robot, or by mechanical means.

STUDENT LIFTOFF



If flying around in space with a rocket on your back sounds like fun, become an astronaut. Only astronauts wear extravehicular activity (EVA) space suits and work outside the Shuttle. Only astronauts use a manned maneuvering unit (MMU) propelled by nitrogen gas. This hand-controlled MMU allows an astronaut to service or retrieve free-flying satellites. For some EVAs, space workers are attached to safety slide wires.

Astronauts have many EVA jobs, including inspecting and photographing payloads, inspecting modular instruments, performing experiments in the cargo bay, repairing damaged Shuttle mechanisms, and operating equipment, tools, and cameras.

Although most work in space can be accomplished by mechanical means, unexpected emergencies need the astronauts' touch.

Space Lab

You will need an adult to help you with this experiment.

How does a space suit protect an astronaut during extravehicular activity?

You need: a paper cup, 2 paper towels, several layers of aluminum foil, tape, a coat hanger wire, water, a thermometer, a burner flame

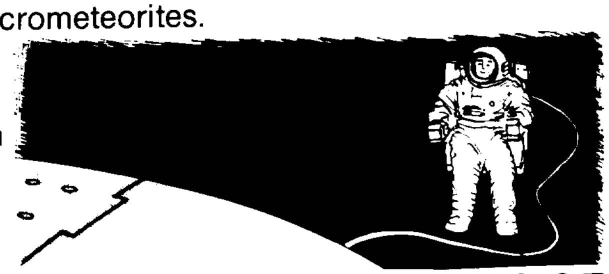
Step 1. Crumble 1 paper towel around the paper cup. Add two layers of foil and another towel. Add a final layer of foil and tape it to the rim of the cup.

Step 2. Shape a coat hanger into a holder for the cup. Fill the cup halfway with water. What is the water temperature?

Step 3. Place the cup in the burner flame for one minute. What is the water temperature now? How does insulating material affect temperature?

Space Countdown

Astronauts wear space suits to protect them from micrometeorites. Iron micrometeorites contain different amounts of iron and nickel.



If 3/8 of an 8-gram micrometeorite is iron, how much is iron? How much is nickel?

If 3/5 of a 6 gram micrometeorite is iron, how much is iron? How much is nickel?

NASA TEACHER RESOURCE CENTERS

Teacher Resource Centers have been established to provide educators with NASA-related educational materials for use in the classroom. The materials, which can be duplicated at the Centers, include classroom activities, lesson plans, teacher guides, filmstrips, computer software, laser discs, and audio and video tapes.

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